COMPRESSED AIR

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR

Vol. XII JULY 1907 No. 5

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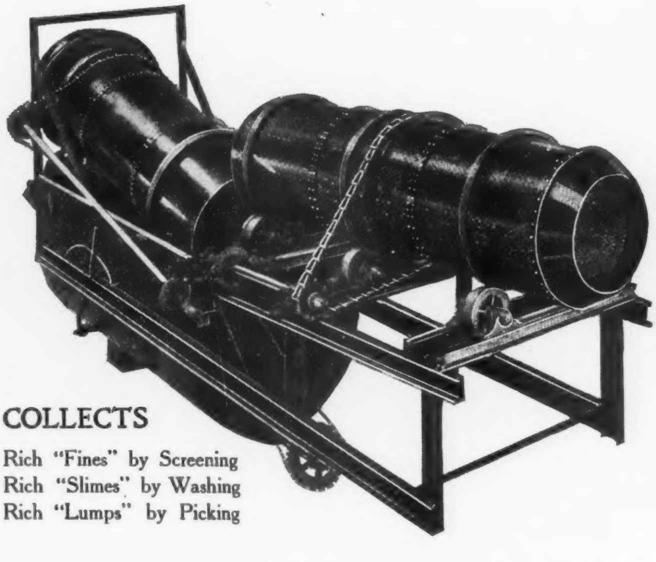
Alphabetical Index of Advertisers, Page 4, Advertising Section.

Clean-Washed Material Permits Accurate Sorting

The "CRANE" SCREEN and WASHER



COLLECTS

Rich "Fines" by Screening
Rich "Slimes" by Washing
Rich "Lumps" by Picking

Complete Plants for CONCENTRATION, CYANIDING, CHLORINATION and SMELTING of Ores

THE STEARNS-ROGER MFG. CO.

Engineers and Contractors

DENVER, COLO.

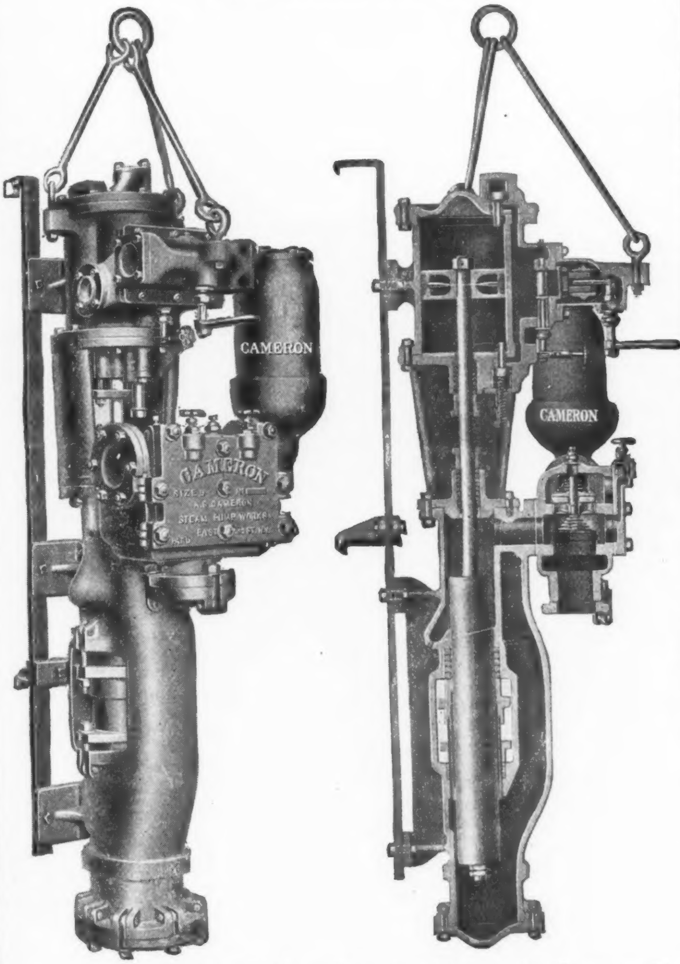
INDEX TO ADVERTISERS.

THE SLOGAN OF THE CAMERON—"CHARACTER: THE GRANDEST THING."

CAMERON PUMPS

Are economical in the best sense. Cost of Maintehance.

JUST AS EFFICIENT WITH COMPRESSED AIR AS WITH STEAM.



These are the outside and sectional views of a Cameron Vertical Plunger Sinking Pump. Look at the construction.

Unsolicited Testimonials Versus Fairy Tales.

Lackawanna Iron & Steel Company,
Wehrum, Pennsylvania'

A. S. Cameron Steam Pump Works,
New York, N. Y.

Gentlemen:—We now have seven of your pumps in use, two of which are your 14 x 8 x 18 Regular Horizontal Plunger Pumps, outside packed. We are required to handle from 1,200 to 1,500 gallons a minute from the faces of each slope while sinking. All of the other pumps in use have two to four times the rated capacity of yours, yet your pumps are regularly, day and night, handling from one to one and one-half times as much water as any of the others, and doing it with less attention and care, and we place greater dependency on these than on any of the others.

Owing to an accident to a duplex pump, one of your pumps is now drowned out and has been for three weeks, and and it is still operating under 275 feet of water, running on compressed air, and handling double its rated capacity, and holding the water sufficiently in check to save two other pumps in the same slope pumping from higher levels. Is it any wonder that we have the highest regard for the "CAMERON" pump?

Yours very truly,
C. R. CLAGHORN, Supt.,
LACKAWANA IRON & STEEL CO.

Electric Light & Ice Company.
Harrison, Arkansas.

A. S. Cameron Steam Pump Works,
New York. N. Y.

Gentlemen:—Express us (Wells Fargo) two brass linings for water cylinder end of your size 3 pump—these are Nos. 16049 and 20063.

Send us information as to removing old lining and installing new.

No. 16049 has operated 18 hours per day since 1895, and has cost us nothing for repairs until the present. No 20063 has been in 24 hours per day since 1900. Its water has been gritty with sand, however, and its water end is in worse shape than the older.

You are to be congratulated on this most excellent record. Working side by side with the old pump, was a condenser feed pump, new duplex——followed by a ——, followed by a———; all of these are now in the scrap pile and the old pump as good as new when the water cylinder is renewed,

Yours very truly,
R. M. FELLOWS, Mgr.,
ELECTRIC LIGHT & ICE CO.

We Build Pumps For Every Service.

To get a better idea of Cameron characteristics—read what users say as well as our Catalogue Edition "G," which will be sent to you on request.

A. S. CAMERON STEAM PUMP WORKS,

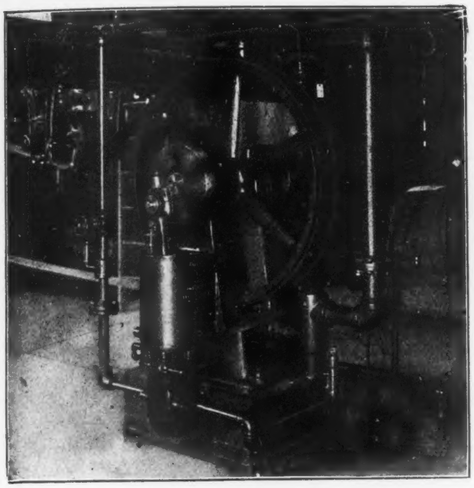
FOOT OF EAST 23D STREET
NEW YORK.

Mar. 1907

"IMPERIAL"

TYPE ELEVEN

AIR COMPRESSORS



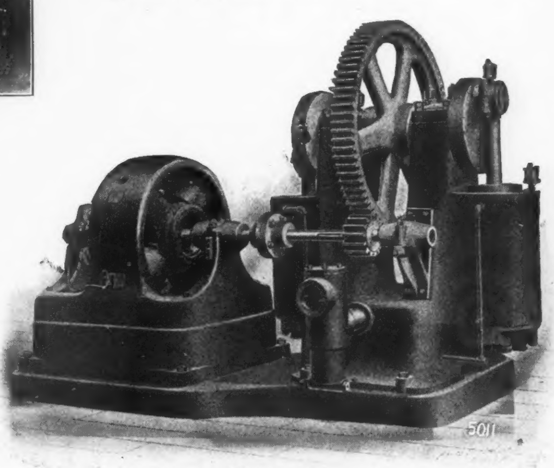
City of Philadelphia Pumping Station.

A vertical, single-acting, power-driven type, duplex or compound, marked by extreme simplicity, great capacity per unit space required, unsurpassed accessibility, automatic regulation, and high efficiency.

A machine designed throughout for heavy service in out-of-the-way places with the minimum of attention. Capacity 16 to 500 cu. ft. per min. Pressures 15 to 100 lbs. Admirably adapted to the small shop or foundry, or for portable service in yard or field.

They are small in dimensions, the largest size occupying floor space only 5½x6 ft., 7½ ft. high.

The driving power required is from 5 to 65 H. P. and any approved method of drive is applicable. Bearings are exceptionally large throughout, materials disposed for maximum strength, ample lubrication provided. The machines, though small in capacity, are as carefully designed and built as the most powerful Corliss type and exemplify Ingersoll-Rand standards of endurance and economy.



Electric Driven "Imperial" Type Eleven Compressor

INGERSOLL-RAND CO.

11 Broadway, NEW YORK

Chicago, Cleveland, Birmingham, Montreal, Lima, Philadelphia, Houghton, Mich., San Francisco, Vancouver, Valparaiso, Butte, Toronto, London, Seattle, Kenora, Paris, Denver, Halifax, Berlin, St. Louis, Pittsburg, Los Angeles, Rossland, B. C., Johannesburg, El Paso, Boston, Salt Lake, Mexico City, Melbourne

U-69

JUST OUT.

OUR

NEW PAMPHLET NO. 18-D.

It gives full particulars regarding steel welding by the THERMIT PROCESS for such repairs as flaws in castings, broken locomotive frames, engine shafts, gear wheels, engine cylinders, machine frames, etc.

THERMIT produces, without the aidtof outside power of any kind, liquid steel a a temperature of 5,400 degrees F. (twice the temperature of ordinary molten steel). This highly superheated liquid steel will melt and unite with any metal with which it may come in contact, forming a single homogeneous mass. It is this property of THERMIT STEEL that is taken advantage of in making the repairs mentioned above.

Send for a copy of the book and learn more about this process.

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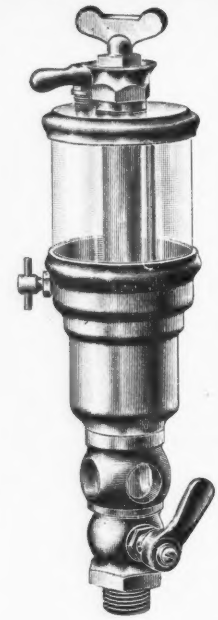

"Graphoil"

AIR COMPRESSOR

Lubricators

will feed a solution of Glycerine and Water, Soap Suds or Oil, WITH or WITHOUT Graphite.

In ice production a solution of glycerine and water, together with graphite, prevents valves sticking and contamination of product.

Comstock Engine Co.,

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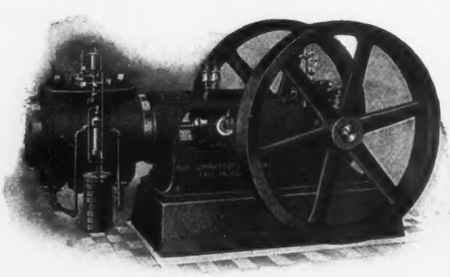
AIR COMPRESSORS



Belt Driven, Class "BB."

Of Single, Duplex, and Two Stage types—Belt, Steam or Motor Driven. Designed for high efficiency and economy of operation.

Our Illustrated Catalogue describes the machines in detail. Mailed free on request.

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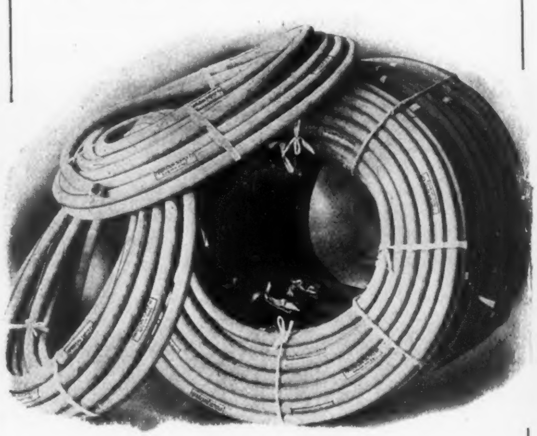
We sell everything pertaining to pneumatic and power Polishing Machinery and pneumatic Tools and supplies for granite polishers.



We illustrate the finest quality Pneumatic Tool Hose manufactured. Send for our handsome illustrated catalogue, containing ninety pages. It is free to all.

Harrison Supply Company

NATHAN C. HARRISON, General Agent

5 and 7 Dorchester Avenue Extension, Boston, Mass.

ALL GOODS GUARANTEED.

COMPRESSED AIR

Established 1896.

A monthly magazine devoted to the useful applications of compressed air.

JULY, 1907.

CONTENTS.

THE ANTECOOLER, THE INTERCOOLER AND THE AFTERCOOLER

By Frank Richards.

These devices are unique among industrial apparatus in that they accomplish desirable results, also of actual, computable commercial value, and yet cost nothing for their working. They consume no raw material and require not even lubrication. The water which flows through them, even when water is scarce, is still as usable as before for boiler feeding or any other purpose.

The cost of these coolers in connection with air compression may be said to consist entirely of the fixed charges, the original cost of the apparatus employed and then the customary allowance for depreciation and maintenance. As to the maintenance, there is no wear or liability of breakage; but there is some oxidation and some deposition of sediment and some clearing out occasionally required, the overhauling thus entailed comparing with the repairs and renewals required for the working and wearing parts of the compressor.

The chief function of the cooler attached to an air compressor is the reduction of the volume of air to be compressed, the reduction of volume entailing a direct proportional saving in the power required. A reduction of 5° Fahr. means a reduction of 1 per cent. in the power required to compress any given quantity or weight of air. There are also important incidental advantages, which will appear later. The air may be cooled before compression by means of an "antecooler"; between two stages of compression, by an "intercooler"; or after compression, in which case the apparatus is called an "aftercooler."

The antecooler is regarded by many as a mere refinement in air compression; yet it works quite as cheaply as the intercooler and there are many cases in which it could be employed with profit, especially in summer, and in all cases where very cold water is available.

THE INTERCOOLER.

The intercooler implies the compound or two-stage compressor, the two stages having the double purpose of avoiding high and dangerous temperatures and of saving power in the second compression on account of the considerable reduction of volume. The intercooler also, until very high pressures are reached, is apt to be regarded as an unprofitable refinement. The question of its utility is, however, not to be determined by opinion or prejudice. It should be approached in the same spirit as the question whether a given compressor should be a single-stage, a two-stage, a 20-inch, or a 24-inch machine, the ultimate question in either case being as to which is the best machine for the purpose intended.

The precise pressures which should be reached in two stages is an open question;

also the upper limit of single-stage compression. In the plants employed in the tunnel work, now going on about New York, we generally find two different systems, and two entirely separate and different sets of compressing apparatus, one for high and the other for low pressure, the former going up to 125 pounds gauge, and the latter being expected to go no higher than 50 pounds. In the service here referred to, the low-pressure compressors work most of the time at 20 to 30 pounds, but there are many compressors in different locations where 50 pounds is the pressure to be constantly maintained, and then the value of two-stage compression may be worth looking into.

COMPARATIVE COST.

Suppose that we have to deliver compressed air constantly at 50 pounds, gauge. taking in air at 60°, and compressing in a single cylinder. Take a 30-inch diameter cylinder at 400 feet piston speed. The free air capacity will be 1,963 cubic feet per minute, the mean resistance for the compression stroke (adiabatic compression) will be 27.39 pounds per square inch, and the horse-power required will be 234.67.

Let us compare this with a system of two-stage compression, with an intercooler between the stages. The diameter of the first cylinder and the piston speed are the same as before, giving an equal free air capacity. We compress in the first cylinder to 25 pounds, this pressure being fixed by the relative capacities of the first and the second cylinders and remaining constant regardless of the final or delivery pressure. The mean resistance, then, in the first cylinder (adiabatic compression) will be 17.01 pounds, and the horse-power will be 145.74.

If the air thus compressed is then cooled to the original temperature, the pressure being maintained, the reduced volume will be inversely as the increased absolute pressure, 40 : 15, or 8 : 3, and for the second cylinder the piston area ratio should be the same, which would make it 18⅜ inches diameter. The mean effective resistance for the second compression, from 25 to 50 pounds, would be 20.84 pounds, and the horse-power would be 66.99, say 67, making the total horse-power $145.74 + 67 = 212.74$, which is apparently a saving of 9 per cent. over the single-stage compression. As the intercooler would probably not cool the air quite to the original temperature, and as the friction of the mechanism as a whole would be slightly increased, the saving would probably be not more than 5 per cent. at the best, so that in compressing to 50 pounds it is doubtful whether two-stage compression with intercooling would be profitable.

WHEN THE TWO-STAGE SYSTEM IS PREFERABLE.

The great majority of compressors in use work at higher pressures than this, say from 75 to 90 pounds, gauge, this being the working pressure for rock drills, and for most of the air-operated tools of the shops. With the same cylinder data as before, 30 inches diameter and 400 feet piston speed, the mean effective resistance in compressing adiabatically to 75 pounds single stage will be 35.23, and the horse-power 301.85. With two-stage compression, compressing in the first cylinder to 30 pounds, the mean effective resistance for this compression will be 19.4 pounds, and the horse-power 166.3. For the second cylinder the diameter would be 17.32 inches, the mean effective resistance 34.56, and the horse-power 98.7, making the total horse-power 265, or a little more than 12 per cent. less than for single-stage compression. Taken inversely, the power cost of single-stage over two-stage compression to 75 pounds, with perfect cooling, is nearly 14 per cent.

To compress to 90 pounds, single stage, the mean effective resistance would be 39.18 pounds, and the horse-power 335.71. Using the same two-stage cylinders as in the preceding case and compressing to 90 pounds, the work of the low-pressure cylinder would be the same as before, and the horse-power the same, 166.3. For the high-pressure cylinder, compressing from 30 to 90 pounds, the mean effective resistance would be 43.41 pounds, and the horse-power 123.97, making the total horse-power 290.27, or nearly 14 per cent. below that for single compression, while in terms of the two-stage compression the excess of horse-power for the single stage would be more than 15½ per cent. The gain here would seem to be beyond question.

DRY AIR AND LUBRICATION.

The intercooler does more than to reduce the horse-power required for a given compression and to secure safe and comfortable working temperatures. It does much to remove what is in some cases the most serious objection to the employment of compressed

air. Dry air can not freeze up, and the intercooler helps to dry the air. This drying of the air is the special function of the aftercooler. The dryness of air is always comparative. The air is at its highest pressure, when it leaves the compressor. If it can then also be reduced to the lowest possible temperature its moisture-carrying capacity will be at a minimum. The air will then be so wet that it will deposit moisture. The water should at this stage be given every chance to drop out, so that, when the pressure falls and the temperature rises, the same air will remain dry air while in use.

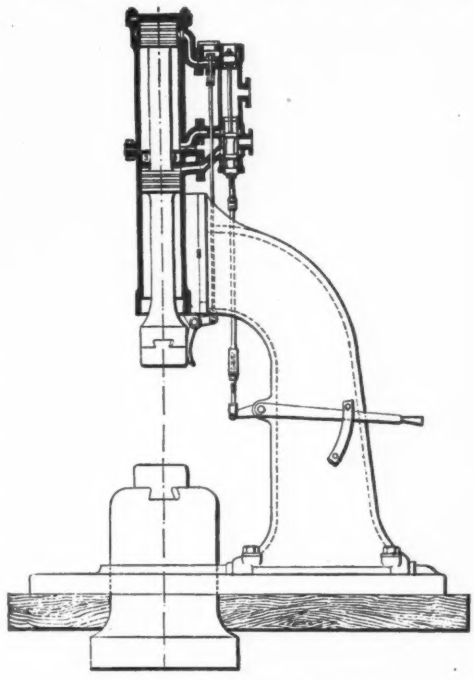
If the air is not cooled, and thus dried before it starts on its course through the pipes, it will begin dropping water as it goes along. In freezing weather in outdoor work, as in quarries, and especially in switch and signal work, the moisture will freeze and gradually choke the pipe, or some of the ice will be carried along to an elbow or to some depression and form a solid obstruction. When the moisture is not in excess in the air there can be no freezing up. In weather which is not freezing the moisture which is precipitated is the cause of "water hammer" and leaky joints. Air which has not been dried by cooling also interferes with lubrication. Oil and water will not mix, and when moisture condenses upon surfaces requiring lubrication the oil can not get at those surfaces.

Any device which thus works so cheaply and accomplishes so much of value, which treats its employer so generously, certainly deserves some appreciation and liberality of treatment in return. We may assume, of course, that the intercooler is sure of employment in two-stage compression and that two-stage compression will be more frequently employed as the economy of it becomes better known, but the antecooler and the aftercooler are also deserving of consideration and should often be employed in situations where they are now unknown. Wherever either is employed the service it renders is so cheap that liberal dimensions, ample cooling surfaces should not be begrudged it.

A NEW COMPRESSED AIR HAMMER

The cut, which we reproduce from *The Engineer*, London, shows a hammer to be operated by compressed air, built by C. & A. Musker, Limited, Liverpool, Eng. This hammer is built in sizes from 3 cwt. to 5 tons, and gives blows of the same energy and quality as when operated by steam. It is announced that the hammer is designed for pressures from 40 to 120 pounds, and this is accompanied by the rather questionable statement that 40 pounds is to be preferred "as it is a well attested fact that the low pressure is more economical to produce, and is a more economical power-transmitting agent, added to which the trouble with pipe joints and leakage is minimized."

The hammer is worked by the hand bar, the



NEW COMPRESSED AIR HAMMER.

same as a steam hammer. Assuming the tup or ram to be at the top and the valve down, as shown, to strike a light blow the valve is moved upward only far enough to admit the air above the lower piston, the same movement of the valve allowing the air under the upper piston to be discharged through the middle part to the lower exhaust.

To raise the tup the valve is lowered sufficiently to allow the air supply to enter the middle port, exhausting the air from above the piston in the lower cylinder through the lower port to the lower exhaust. The miter valve is opened by the exhausting of the air.

To give a heavy blow, the valve is moved upwards, allowing the air to go through the upper port under the miter valve, and to act upon the upper side of the upper piston and at the same time through the center of the valve to the lower port, and to act upon the top of the lower piston, the air thus acting on both pistons at the same time.

For the upward stroke, the valve is reversed; air pressure is admitted underneath the upper piston through the middle port, and the air above the two pistons is exhausted through the higher and lower ports respectively.

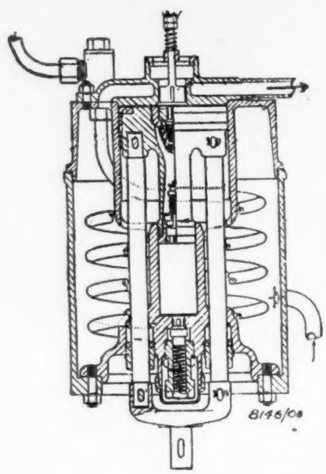
The miter valve is for the purpose of using the air expansively, without wire-drawing, when striking heavy blows. It is arranged to be kept open by a curved bar resting against the tup until the latter descends about half stroke, when the lever is freed and the valve descends, cutting off the supply, the remainder of the stroke being driven by the expansion of the air.

Economy in working results from both the using of the lower piston only for light blows and from the expansive use of the air when the upper piston with the larger area is used. A comparative test of air hammers was made by Sir William Armstrong, Whitworth & Co., Limited, with the result, as stated, that the Musker hammers used less than half the air required for the others.

USELESS TWO-STAGE COMPRESSION

It is, we suppose, generally understood, at least by our readers, that there is no reason for two-stage compression of air except for the opportunity it provides for the cooling of the air between the stages and the reducing of its volume before the second compression. In this way the high temperatures, always objectionable as to lubrication, and sometimes dangerous as causing ignition and explosion, are avoided, and the reduction of volume results in a distinct saving of power.

A recent British patent for an "Improved" Two-Stage Air Compressor—the inventor an Italian—is of interest chiefly as showing how completely the essential conditions of economical—as well as safe—air compression can be ignored. In this compressor, shown in the sketch, there are two vertical open-ended air cylinders, the larger one above. A single piston is provided with a large end fitting the upper cylinder and a small end fitting the smaller cylinder below, the piston of each cylinder being single acting. The piston is actuated by two rods attached at each end of the enlarged head of the piston and united by a yoke below. Starting from the position shown, the piston descends and the upper cylinder is filled with air, which enters by a central valve at the top. When the piston rises this air passes down through the middle of the piston into the smaller cylinder, the transfer into the smaller cylinder practically compressing the air. A valve in the piston closes and when the piston descends this charge of air is expelled, passing through a valve in the bottom of the cylinder. In the meantime the upper cylinder has been filled again, and so the operation goes on. There has been not the slightest provision for cooling the air all through the compression. The compressed air now passes through the pipe coil in the water chamber surrounding the cylinders and is then probably well cooled, but too late to have the good effect which should have been expected.

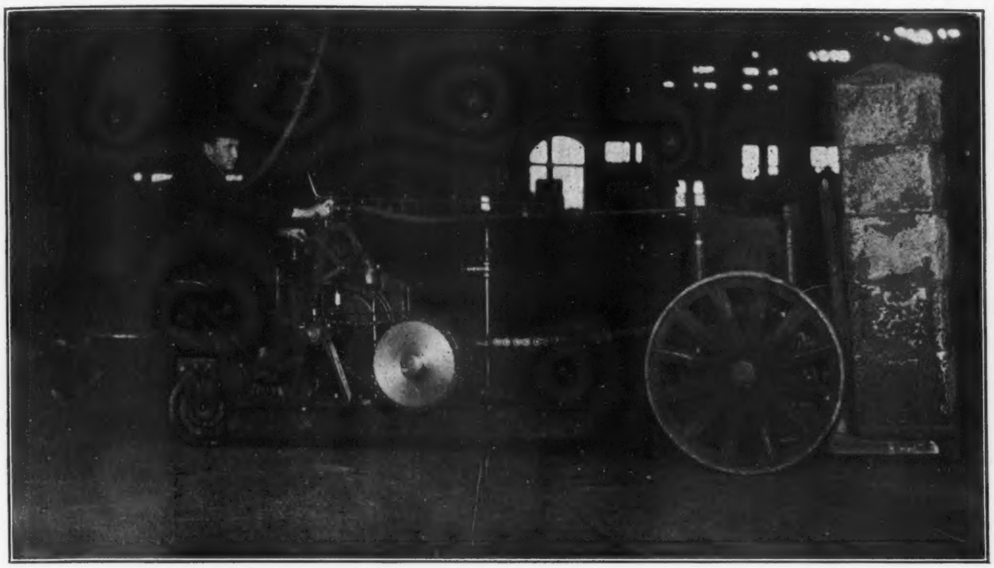


USELESS TWO STAGE COMPRESSION.

It is claimed for this arrangement that certain valves, packings, stuffing boxes, etc., are gotten rid of. If the compression had all been done in the upper cylinder with an inlet and an outlet valve in the top, how much simpler it would have been. In this case, besides the multiplication of parts, the two stuffing boxes, through which the vertical rods pass, should not be overlooked.

AIR OPERATED TRUCK FOR MALLEABLE IRON FURNACES

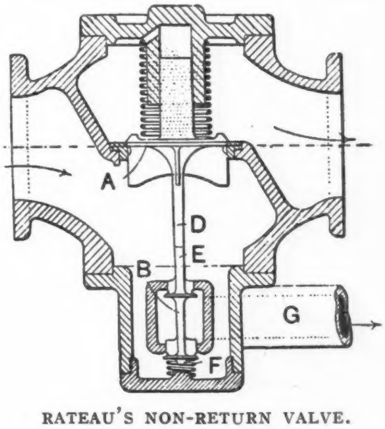
The half-tone shows a charging truck in successful use in malleable iron foundries. The truck is connected to the air supply by a long suspended hose, which gives it room to travel back and forth in front of the furnaces and to run in or out of them, as required. The truck is three-wheeled, the third wheel under the drivers' seat, and the locomotive is accomplished by a Dake engine chain-connected to the wheels. The lifting of the annealing boxes is done by a vertical slide with projecting toes which go under the box, or a pile of boxes, lifting only high enough to clear the ground, and when the truck has carried the load to the point required letting it down again. There is an air cylinder of sufficient diameter, the piston of which operates the vertical slide for the lift. The capacity of the machine is 100 tons per day, and to operate it requires about 200 cubic feet of free air per minute at various pressures, according to the load. This truck may be another means of introducing the air compressor, and when it is in use then may come calls for pneumatic tools, then for a larger compressor, and so on.



AIR OPERATED TRUCK FOR MALLEABLE IRON FURNACES.

RATEAU'S NON-RETURN VALVE

If one is dealing with a centrifugal fan drawing from the atmosphere and discharging into a reservoir in which the air is already under pressure, it is necessary to arrange between the delivery outlet of the fan and the reservoir a non-return valve which will automatically close and prevent the air in the reservoir escaping when the pressure of the fan is insufficient. During the working of the fan, so long as the speed of rotation fails to reach a sufficient value, the fan produces a



RATEAU'S NON-RETURN VALVE.

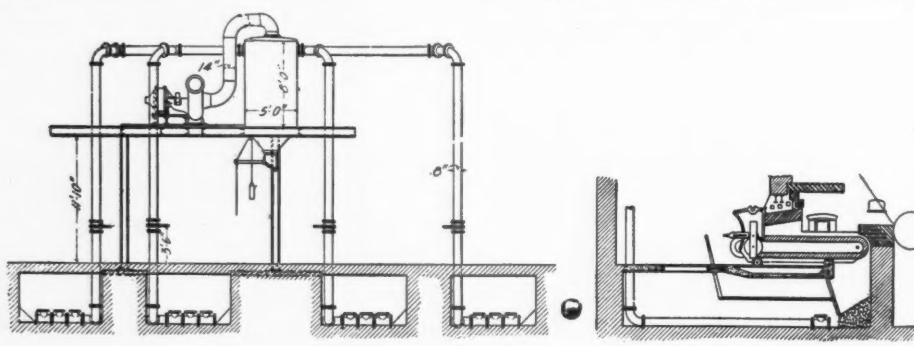
pressure too small to open the valve, and the output is nil. Under these conditions the elastic fluid acquires within the apparatus a pulsatory movement, flowing and returning alternately at periods of time which vary according to circumstances. This pulsatory action persists, and causes a loss of energy and considerable heating of the fluid to take place.

To obviate this objection the device shown in the accompanying illustration has been patented by Mons. A. Rateau, of 20, Rue d'Anjou, Paris. When the output of the fan falls to a value such that the pulsatory action can come into existence an escape orifice is opened. In the illustration A is a non-return valve arranged on the conduit leading from the fan to the reservoir. B is the valve (in the example a double-beat balanced valve) which closes the escape pipe G during normal working but which opens when the non-return valve A closes. This is brought about simply by the contact of the extremity of the stem D of the valve A with the extremity E of the stem of the valve B. As soon as the valve A is raised by the pressure of the gaseous current becoming sufficient, it allows the valve B to be acted on by the spring F, which closes it against its seat.

PNEUMATIC ASH-CONVEYOR SYSTEM.

In boiler plants the problem of handling ashes is solved in many ways more or less economical. A recent issue of the *Electrical Review* describes a system which is entirely new and original. At the Evanston (Ill.) plant of the North Shore Electric Company there is a pneumatic ash-conveyor system that has shown itself capable of disposing of ashes in a satisfactory and very economical way. The essential parts of this system for pneumatically handling ashes are a No. 7 Sturtevant exhaust fan direct-driven by a 40 H. P. motor. A 14-inch pipe connects the fan with the top of a "separator." Leading into this separator are 8-inch wrought iron pipes, which extend to the ash pits under the grates, where openings are provided for allowing the ashes to pass into the pipes. On account of the expense which would have been necessary to place one ash-collector header through the row of ash pits, as in other installations, it was in this instance thought best to use more piping in the form of risers as shown in the drawing. The separator is mounted between two of the boilers, and at the rear, at such an elevation that a wagon may be driven under it and loaded with ashes from a track. The small headroom limited the capacity of this separator to 8,000 cubic feet, but for installations in power plants of more modern design it is proposed to place a concrete ash bunker just below the separator so that a large storage capacity may be had.

When it is desired to empty the ash pits the exhaust fan is started, thus creating a vacuum of about one pound per square inch in the separator and the pipes connected with it. This vacuum rapidly draws the ashes that have accumulated around the openings in the ash pits into the pipes and through them to the separator, where, by means of a spray head and baffles they are wet down and discharged to the bottom of the separator hopper. Blast gates are provided in the lead from each ash pit so that if desired each pit may be cleaned individually. Due to the great difference in velocities of the air, which in the pipes connecting with the ash pit and serving to carry



PNEUMATIC ASH-CONVEYOR SYSTEM.

away the ashes is 18,000 feet per minute and in the separator but 500 feet per minute, there is no trouble from ashes passing the separator, and damaging the exhaust fan. It is also observed that the ashes travel through the center of the space in the pipes, rather than along the sides. This is due to the greater velocity of the air in the center where the friction is less and thus the pipe work is free from the wear that would ordinarily be expected.

Before this system of handling ashes was installed at the North Shore plant it required four men ten hours a day to keep the ash pits clean. It was first necessary to go into the hole, shown in the drawing, in front of the boilers and shovel the ashes from their piling place back 12 feet to a point under the hole; then they had to be handled again and thrown on to the boiler-room floor where a third handling was necessary to load them for carrying out of doors. With the new ash-handling equipment one man does the work of the four in one-fifth of the time or two hours; thus, the economy of the installation, which only requires about 25 H. P. motor capacity during such times as ashes are being removed, is made apparent. As ordinarily operated the ashes are removed at the rate of 300 pounds per minute and by varying the speed of the motor both ashes and clinkers may be handled in quantities up to 500 pounds per minute.

A YELLING LIGHTHOUSE

On the French coast there will soon be a lighthouse equipped with monster mouths and a compressed air device, which will enable it to shout, in tones of thunder, to ships on the horizon. The invention by Dr. Marage, an ear specialist of Paris, is not a phonograph or anything like it, but an exact imitation of the human throat and mouth, with an air pump for lungs.

Teeth, lips, jawbones and all are imitated exactly. Dr. Marage's small models, hardly appreciably larger than the normal human mouth, can be made to utter a faint whisper or give vent to an ear-splitting yell such as no man ever made.

With a mouth six feet from corner to corner, it is estimated that the artificial voice could be understood from three to six miles away, according to weather conditions. Mouths of this size are to be placed beneath the lens of the new French lighthouse.—*Exchange Unidentified.*

DRILLING BOLT HOLES IN GREEN CONCRETE

The drilling of bolt holes in partially green concrete is a tedious process, owing to the wedging of the drill. One contractor seems to have hit upon a simple method of drilling these holes and at the same time avoiding the delay caused by the wedging of the drill. He used a compressed air drill hung on the guides of a small pile driver frame, the drill occupying the same position the hammer would occupy in pile driving. The drill was suspended by a wire rope and raised or lowered by means of a hand windlass. One of the advantages of this arrangement was that a longer drill could be used than by the ordinary tripod arrangement. A small metal pipe was carried into the hole with the drill, and through it water was forced under heavy pressure, carrying off the chips and thus preventing wedging. Many of the holes were bored in partially green concrete to a depth of 6 feet or over.—*Engineering Contracting.*

Some idea of the immense driving force that can be attained by compressed air will be realized when it is stated that under a pressure of about 2,000 pounds, a shaft of air penetrating through an orifice—no larger than a tiny pin point—would instantly bore a hole through a 2-inch plank of solid oak.

The above compressed air wonder has been started on its circuit of the pseudo-technical press, and we are likely to see it doing frequent duty as a column filler. Who first "stated" it is not known, nor is it known who has done the trick.

THE FLOW OF AIR IN LONG TUBES, WITH SPECIAL REFERENCE TO PNEUMATIC DISPATCH

By B. C. Batcheller.

PART IV.

Culley and Sabine's Experiments.‡

In a paper read before the Institution of Civil Engineers, London, Messrs. Culley and Sabine give the results of some experiments made with the small pneumatic tubes of the London post office, connecting central and branch offices. From the data obtained in these

‡See Proceedings Institute Civil Engineers, London, Nov. 16, 1875; "Pneumatic Transmission of Telegrams."

experiments it is possible to compute the co-efficient of friction. The tubes were of lead, 0.1823 ft. inside diameter, slightly moist from condensation. The time of transit was obtained by dispatching a light felt carrier through the tube. The pressures were measured by mercury manometers. From the data given in table D, p. 79, of Messrs. Culley and Sabine's paper, the co-efficient of friction has been computed by the use of formula (35), and results tabulated below. The temperature of the air in the tube is not given for each experiment and was evidently not measured. The paper states: "Some observations were made on the temperatures of different tubes, the results of which were very various. Generally, however, the temperature of the air in issuing is lower than on entering a tube, but not to the exent corresponding with the expansion. As an instance, the following observations at different points of the Cannon street tube showed that the actual fall of temperature through the expansion is, from these causes, rendered comparatively little."

	Central Sta. Deg. Cent.	Cannon St. Deg. Cent.	Thames St. Deg. Cent.
Temperature of air in pressure pipe	26°.6	10°.0	13°.8
Temperature of office from which air was drawn	17°.7	15°.5	15°.5
Temperature of air in vacuum pipe	13°.3	12°.7	13°.3

In computing the coefficient of friction the temperature has been assumed in all cases to be 60° Fahrenheit.

CULLEY AND SABINE'S EXPERIMENTS.

d=0.1823. PRESSURE.

No. of Experiment.	Distance Feet. L	Initial Absolute Pressure Pounds Per Sq. Inch. P_1	Final Absolute Pressure Pounds Per Sq. Inch. P_2	Time of Transit Seconds t	Coefficient Of Friction f Computed by (35)	Mean Carrier Velocity um	Tube Between Central Station and
1	5523	22.7	14.7	175	0.006133	31.56	Thames St.
2	4923	21.2	14.7	173	0.007224	28.46	Mark Lane
3	4227	22.83	14.7	121	0.006617	34.93	Fenchurch St.
4	4014	23 2	14.7	106	0.006126	37.78	Eastcheap
5	3576	20.2	14.7	104	0.005960	34.38	Baltic Coffee House
				Mean.............	0.006412		

VACUUM.

6	5523	14.7	22.7	145	0.006924	38.10	Thames St.
7	4923	14.7	21 2	140	0.007188	35.16	Mark Lane
8	4227	14.7	20.95	108	0.006460	39.14	Fenchurch St.
9	4014	14.7	19.95	118	9.007374	34.02	Eastcheap.
10	3867	14.7	19.95	108	0.006908	35.81	Gresham House.
11	2895	14.7	20.2	67	0.006683	43.21	Cornhill,
12	2862	14.7	20.2	70	0.007550	40.90	Lloyds.
13	2751	14.7	19.95	68	0.007607	40.46	Telegraph St.
14	2424	14.7	20.2	54	0.007395	44.90	Founders Court.
15	2331	14.7	19.2	54	0.006618	43.17	Ludgate Circus.
				Mean.............	0.007071		

Mean of all experiments—$\mathbf{f} = 0.006851$.

For a tube 0.1823 ft. diameter, Prof. Unwin's formula gives

$$\mathbf{f}\ 0.0027\left(1 + \frac{3}{10 \times 01.823}\right) = 0.007143$$

Arson's Experiments.

Prof. Unwin has compiled the results of several experiments on the flow of air in long pipes (to be found in the minutes of the proceedings of the Institute of Civil Engineers, London), from which I will make some quotations:

"In the Cours d'Hydraulique of M. Phillips, page 300, there are given the results of some experiments on the flow of air, by M. Arson. The co-efficient of friction was found to vary sensibly with the velocity and M. Arson adopted the well-known expression

$$\mathbf{f} = \frac{a}{v} + b$$

for the co-efficient of friction, in which a and b are constants and v is the velocity of air in feet per second. Reducing M. Arson's results to foot and pound units, the following values of a and b are obtained for cast-iron pipes:

Dia. of pipe, Feet.	a	b	f For 100 feet per second.
1.64	0.00129	0.00483	0.00484
1.07	0.00972	0.00640	0 00650
.83	0.01525	0.00704	0.00719
.338	0.03604	0.00941	0.00977
.266	0.03790	0.00959	0.00997
.164	0.04518	0.01167	0.01212

It will be seen that at velocities exceeding 20 or 30 feet per second the first term $\frac{a}{v}$ in the expression for **f** varies very greatly with the diameter of the pipe, as is known to be the case with water."

Interpolating in the above table, for a tube 6⅛ in. diameter (0.5104 ft.) a = 0.0248 and b = 0.0086; for a tube 8⅛ in. diameter (0.6778 ft.) a = 0.019 and b = 0.0079. Using these values in the expression

$$\mathbf{f} = \frac{a}{v} + b$$

we have computed the following table for the purpose of comparison with the experiments made in Philadelphia:

Velocity feet per second.	f for d = 0.5104 $\frac{a}{v} + b$.	f or d = 0.6778 $\frac{a}{v} + b$
20	0.00984	0.00885
30	0.00943	0.00853
40	0.00922	0.00837
50	0.00910	0.00828
60	0.00901	0.00822
70	6.00895	0.00817

These values of **f** are much greater than those obtained from my experiments, but the difference may be partly due to the rough surface of the cast-iron pipes with which M. Arson's experiments were made. There is less variation with the velocity than my results show.

Stockalper's Experiments.

In 1879 M. Stockalper published a pamphlet at Geneva, in which he gives the results of experiments made at Saint Gothard's tunnel on the flow of compressed air in long metallic conduits for the transmission of power. The experiments were made with two pipes, one 20-c.m. (0.656-ft.) diameter, 4600 metres (15,092 ft.) long, partly of cast, partly of wrought iron, having joints made with flanges, bolts and rubber gaskets; the other 15-c.m. (0.492-ft.) diameter, 522 metres (1713 ft.) long, of wrought iron, having joints made in the same manner.

The velocity of the air in the piper was computed from the revolutions of the compressor, the volumetric efficiency having been determined by a previous experiment in filling a reservoir of 166.50 cubic metres capacity. The pressure in the pipes was measured with Bourdon gauges, on which 1/20 of an atmosphere could be read and a curve of corrections was made for each gauge by comparison with a manometer. The temperature of the air was measured by means of thermometers inserted into the pipe and corrections applied for the exterior pressure on the thermometers.

M. Stockalper attempts to show that Darcy's formula for the flow of water can be applied to the flow of air if the results be multiplied by the ratio of the densities of water and air, but it is obvious that such a formula, neglecting as it does, the work of expansion, can not give correct results.

In the table on the next page Stockalper's results have been reduced to English units and the value of the co-efficient **f** for each experiment computed.

By the Unwin formula, for a pipe 0.656 ft. diameter—

$$\mathbf{f} = 0.0027\left(1 + \frac{3}{10 \times 0.656}\right) = 0.00393$$

and for a pipe 0.492 ft. diameter—

$$\mathbf{f} = 0.0027\left(1 + \frac{3}{10 \times 0.492}\right) = 0.00435$$

As the air flowed through the pipes, the temperature rose 9° C., by conduction of heat through the walls of the pipe, which would

EXPERIMENTS ON THE RESISTANCE OF THE PARIS AIR MAINS.

Number of Experiment.	Distance. Feet. L	Initial Absolute Pressure. Pounds. P_1	Final Absolute Pressure. Pounds Corrected. P_2	Initial Velocity. Feet per Second. u_1	Mean Velocity. Feet per Second. u_m	Coefficient of Friction. f	Description of the Pipe Line.
1	54278	106.6	86.15	24.69	27.20	0.00229	Entire Pipe Line.
2	54278	114.4	87.25	23.09	26.02	0.00316	" " "
3	54278	119·4	105.36	17.82	18.90	0.00280	" " "
4	54278	116.1	109.44	13.31	13.70	0.00253	" " "
5	54278	114.1	110.42	10.99	14.25	0.00212	" " "
6	14467	116.1	112.65	16.55	16.79	0.00323	Rue de Charoune.
7	14467	119.4	117.32	10.83	10.92	0.00445	" " "
8	14467	114.4	107.23	23.09	23.81	0.00344	" " "
9	14467	119.4	114.34	17.82	18.20	0.00395	" " "
10	10982	102.9	100.50	20.68	20.92	0.00214	Fontaine; Sta. I
11	28776	112.5	109.87	13.71	13.87	0.00187	Charoune; Fontaine
12	10982	107.7	107.20	14.31			Fontaine; Sta. I
13	14520	113.9	111.01	14.40	14.58	0.00364	Station I;
14	14520	108.3	106.64	16.06	16.18	0.00181	Rue de Charoune,

d = 0.980 feet. Mean............0.00288

have the effect of reducing the value of *f* slightly. The results clearly show a reduction in the co-efficient as the diameter of the pipe increases, and with the larger pipe the co-efficient diminishes slightly as the velocity increases. These experiments seem to merit a good deal of confidence on account of the large scale on which they were made and the care that was taken to reduce the errors.

Weisbach's Experiments.

Quoting again from Prof. Unwin's paper:

"The great influence of the diameter of the pipe on the co-efficient of friction seems also to explain the differences between Stockalper's results and those of Weisbach. Weisbach had given for the co-efficient of friction of air values ranging from 0.012 to 0.028, or values from four to seven times as great as those obtained by M. Stockalper. Weisbach's expernments were made in small tubes about 2 metres long, at velocities of 80 to 490 ft. per second, and therefore the results do not merit great confidence. Still, if the very small diameter of the tube is allowed for, they diverge much less from M. Stockalper's results than they appear to do at first."

The following are some of Weisbach's results:

	Diameter. Feet.	f
Brass and Glass Tube	0.033	0.014 to 0.027
" " " "	0.047	0.012 to 0.026
Zinc	0.080	0.013 to 0.023

By the Unwin formula

For d = 0.033	f = 0.0272
d = 0.047	f = 0.0199
d = 0.080	f = 0.0128

Riedler and Guthermuth's Experiments.

A most important series of experiments on the resistance of the Paris air mains was made by Professors Riedler and Gutermuth. They merit especial attention because of the large diameter and great length of the pipes. The volumetric efficiency of the air compressors was first determined and then the quantity of air delivered to the mains was computed from the number of revolutions of the compressors. The pressure was measured at several points along the mains. It was necessary to make corrections for leakage and for the resistance of draining traps, draining tanks and stop-valves. Prof. Unwin has reduced these experiments to English units and made the corrections.§ The table on page 4507 contains the results of his computations. The diameter of the pipes was 30 c.m., or 0.98 ft.

Siemen's Experiments.

Dr. W. Brix describes a series of experiments made by Dr. Siemens: Sufficient data is given to enable us to compute the co-efficients of friction, although they do not merit much confidence, for the experiments were not made with much precision.

§"On the development and transmission of power." Unwin; p. 219.

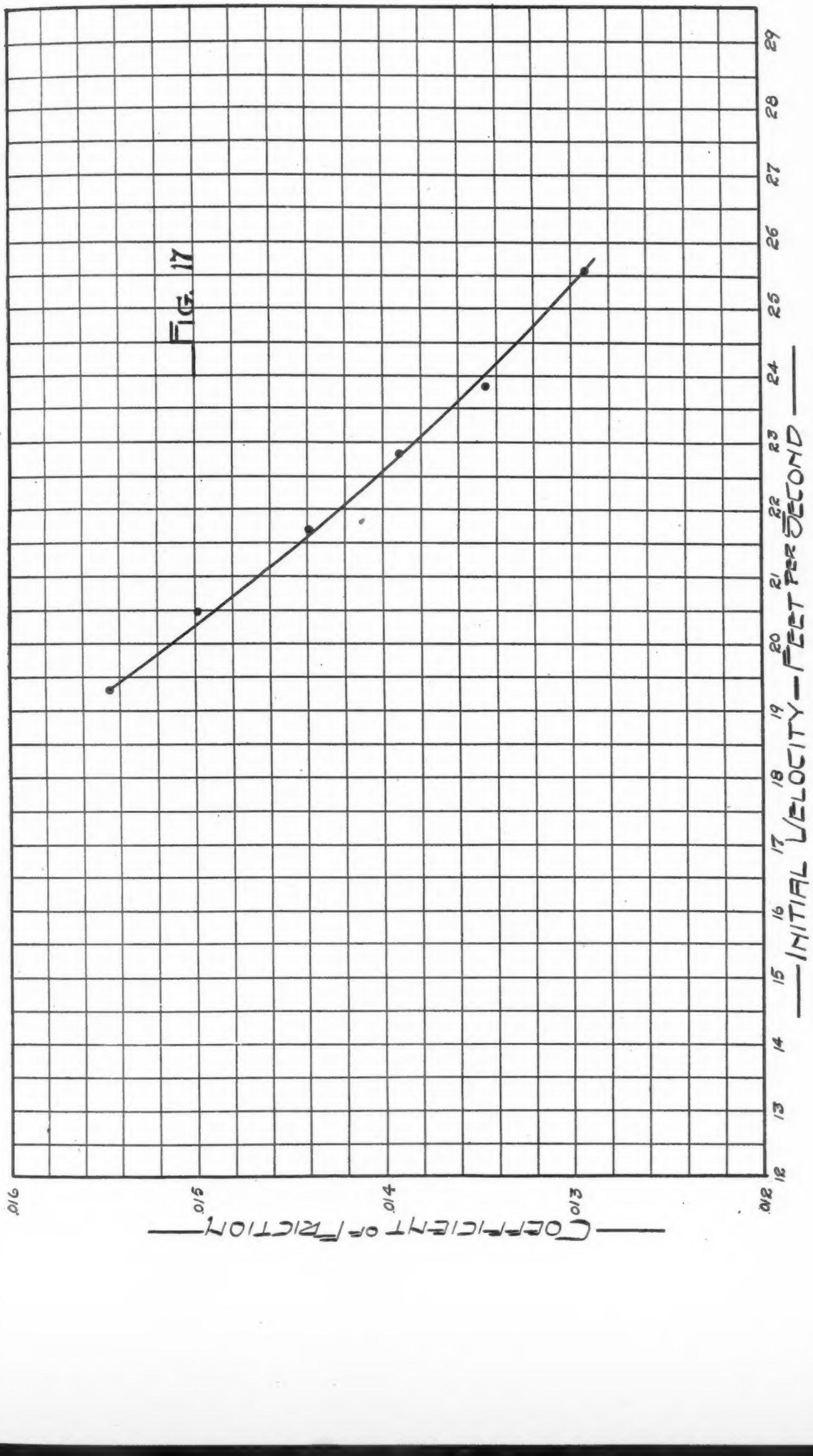


Fig. 17
Initial Velocity—Feet per Second
12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Coefficient of Friction
.016 .015 .014 .013 .012

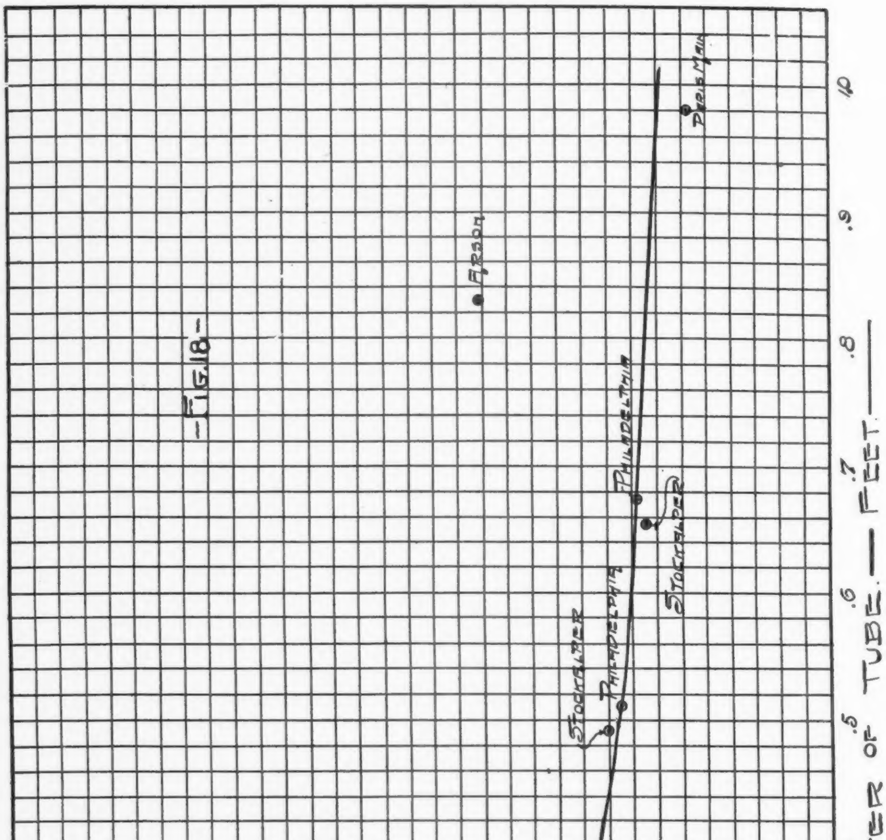


FIG. 18
DIAMETER OF TUBE — FEET
COEFFICIENT OF FRICTION
WEISBACH
SIEMEN
ARSON
CULLET
STOCKALPER
PHILADELPHIA
PARIS MAIN
.1 .2 .3 .4 .5 .6 .7 .8 .9 1.0
0 .001 .002 .003 .004 .005 .006 .007 .008 .009 .010 .011 .012 .013 .014 .015 .016

STOCKALPER'S EXPERIMENTS.

Experiment.	d Diameter of the pipe, feet.	L Length of Pipe, Feet.	W Weight of Air Flowing per Second, Lbs.	Mean Velocity, Ft.	P Pressure at beginning of Pipe, Lbs. per Sq. Ft.	P Pressure at End of Pipe, Lbs. per Sq. Ft	T Mean Absolute Temperature.	f
I.	0.656	15092	2.669	19.32	11.852	11.090	531	0.00347
	0.492	1713	2.669	37.14	11.090	10.582	540	0.00450
II.	0.656	15092	1.776	16.30	9.207	8.741	531	0.00366
	0.492	1713	1.776	30.82			540	
III.	0.656	15092	1.483	15.58	8.217	7.725	531	0.00410
	0.492	1713	1.483	29.34	7.725	7.503	540	0.00447

Mean coefficient for 0.656 ft. pipe 0.00374.
" " " 0.492 " " 0.00449.

The method of making the experiments was to maintain a constant pressure in a tank and allow the air to flow from the tank through an experimental tube, then through a gas meter into the atmosphere. The pressure was observed and the quantity of air flowing was measured by the meter. No temperatures are recorded. The tubes were of lead.

The second table on page 4507 gives some of the results reduced to English units, with the values of **f** computed.

These results are interesting because they show a remarkably uniform variation of the co-efficient with the velocities, made even more apparent by plotting them and drawing a curve as has been done in Fig. 17. The values of **f** are about one-third the value obtained from the Unwin formula, but the tube was extremely small, so it is quite possible that the formula does not give correct values in such an extreme case.

Conclusions.

After a careful study of the results of all these experiments, we seem to be justified in drawing three conclusions: First, the co-efficient of friction varies with the diameter of the tube; second, Prof. Unwin's empirical formula expresses the relation of the co-efficient to the diameter of the tube as accurately as it can be stated until we have more experimental data; third, the co-efficient of friction probably varies with the velocity of the air.

The results of all the experiments are plotted in Fig. 18, and the curve of the Unwin formula is drawn with the same coördinate axes to show how closely the curve fits the experiments. The ordinates are values of **f** and the abscissa diameters of tubes. The Paris, Philadelphia, Stockalper and Culley-Sabine experi-

SIEMEN'S EXPERIMENTS.

No. of Experiments.	Initial Absolute Pressures Inches of Mercury.	Final Absolute Pressures Inches of Mercury.	Final Veocity Feet per Second u_2	Initial Velocity Feet Per Second u_1	Coefficient of Friction **f**
16	36.22	29.86	23 28	19.33	0.01543
18	37.00	29.86	25.34	20.49	0.01498
20	37.79	29.86	27.40	21.69	0.01440
22	38.58	29.86	29.46	22.84	0.01387
24	39.37	29.86	31.42	23.87	0.01345
26	40 15	29.86	33.17	24.72	0.01322
28	40 94	29.86	35.02	25.59	0.01292

L=358.4 d=0.02146

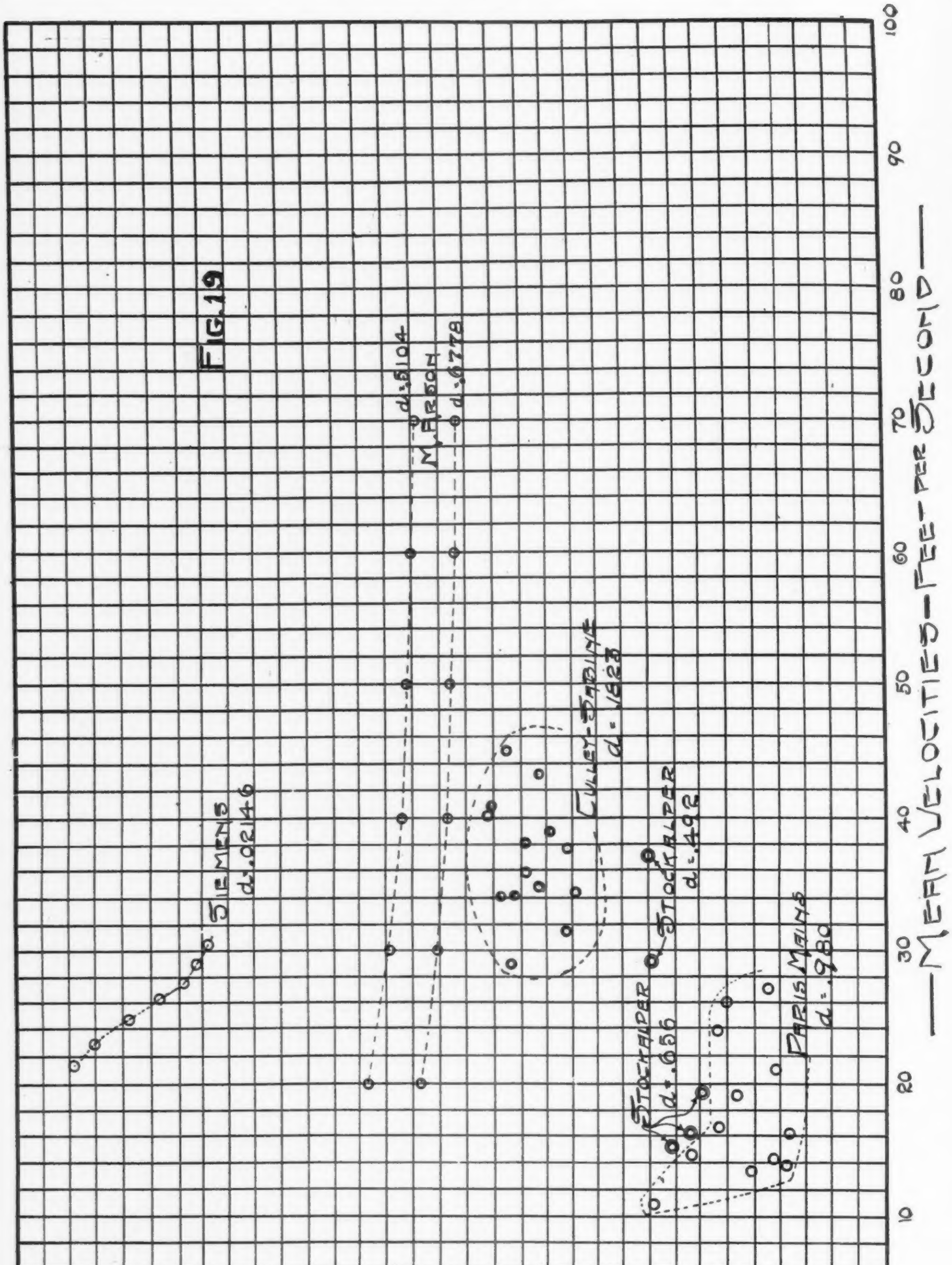


FIG. 19
SIEMENS
M. ARSON
STOCKALPER
STOCKALPER
PARIS MAINS
MEAN VELOCITIES — FEET PER SECOND
COEFFICIENT OF FRICTION

ments lie most nearly on the curve, and they are probably the most reliable. Perhaps if all the results could be reduced to a common velocity they would lie more nearly on the curve.

The value of **f** varies much less with the velocity of the air than with the diameter of the tube; therefore, experiments of a higher degree of precision are required to show the former relation. Besides my experiments in Philadelphia, the experiments of MM. Arson and Siemens clearly indicate such a relation. Stockalper's results show a tendency in this direction, and it requires only a little stretch of the imagination to see the effect of velocity in the experiments with the Paris mains. Culley and Sabine's results do not throw much light on the subject, since they extend over such a limited range of velocities. No doubt all of these experiments would have shown a variation of the co-efficient with the velocities had the range of velocities been greater.

The results are all plotted to the same scale in Fig. 19., with values of **f** for ordinates and velocities for abscissa, showing at a glance what each contributes.

This is a fruitful field for research, and it is to be hoped that other investigators will give us more light on the subject.

(*The End.*)

LIQUID AIR IN METALURGY

It is generally assumed that at very low temperatures metals become brittle and even fragile, and in numerous cases the breaking of steel rails in winter weather has been attributed to this cause. By the use of a bath of liquid air it has been found practicable to test various metals and alloys at temperatures as low as—180° C., and this has led to the discovery that while many steels have their tensile strength increased, their ductility lowered and their brittleness raised at low temperatures, this is not always the case. R. A. Hadfield, a well-known British metallurgist, has shown that a nickel manganese steel can be made which will be as tough, if not tougher, at—180° C. than it is at ordinary atmospheric temperatures, and this, too, without material change in tensile strength. Liquid air has also been used for quenching specimens after tempering, and some instructive information has been obtained about the process of hardening in this way.

THE PROPER INSTALLATION AND USE OF COMPRESSED AIR IN RAILWAY SHOPS AND MANUFACTURING ESTABLISHMENTS*

By W. P. Pressinger.

During the last five years much progress has been made toward the standardizing of operations with air tools, hitherto accomplished by different means in different shops; also, we are witnessing the realization of prophecies regarding the extension and wide-spread use of air-power which seemed wildly extravagant when they were made. From the air-brake pump to the Corliss compressor is a wide reach, yet many have seen their air-power plant develop from one to the other during the past ten years.

I shall merely mention in passing the familiar applications of the air hammer for chipping, riveting, scaling, or any service demanding a rapid, hard, percussive blow; the air motor for drilling, reaming, flue rolling, turning car journals, or any kind of work requiring rotative power; the air hoist, either in the form of a motor or a straight-lift cylinder and piston. Likewise may be mentioned the pneumatic jack, the sand blast, the stay-bolt nipper, the paint burner and the paint sprayer, the air-cleaning nozzle and numerous other special uses devised for this readiest of powers.

The application of compressed air for raising water from bored wells represents a steadily widening field in which compressed air has no rival. Especially is this form of compressed-air usefulness coming into more general service with railroads; not only does the air lift yield more water with less power expenditure, but the possibility of producing compressed air at one power plant and conveying it without appreciable loss to as many pumping points as desired, entirely eliminates the cost and maintenance of the separate pumping plant at the well.

Electricity is the desirable long-distance transmitting agent, and as such is employed to a wide extent in utilizing distant water powers for compressing air at the operating point for driving drills, hoists, pumps, etc. Similarly in industrial plants of large area, motor-driven compressors may be found dis-

*Abstracted from Proceedings of Central Railway Club.

tributed at points of chief consumption, the transmission of the electric current being preferable to the initial cost, inspection and maintenance of long-distance air mains. Many main power plants have large compressors motor driven when conditions favor this form of drive.

Therefore, in its own unique field, by reason of properties peculiarly its own, compressed air remains in undisputed possession.

Forcing recognition in the beginning by reason of their wonderful labor economies, air tools have gained an established place, not originally conceded, partly because of the great strides accomplished toward higher efficiency in the selection and installation of compressed-air plants.

It is natural to expect that larger compressing units would produce compressed air with less relative expenditure of power, since the opportunity exists for refinements of design and construction not possible in the smaller compressors. But so great has been the demand for a reduction in the cost of compressed air production that contemporary compressors in all sizes are vastly superior to the earlier patterns in use when air tools were first introduced. This has been accomplished through an intelligent appreciation by the builders of air-compressing machinery of the more arduous service which compressors undergo, to which they have responded by designing machines adequate in weight, strength, bearing surfaces, valve areas and automatic regulation, to the severer conditions. Users of compressed air in the selection of their compressors have contributed an influence equally beneficial by exercising a discriminating knowledge and judgment (expensively obtained in the school of experience) which they did not possess when compressors first supplanted air-brake pumps.

An evil to which not overscrupulous compressor builders have contributed is the overrating of compressor capacities. As is well known, compressors are rated according to their piston displacement, this being the cylinder area multiplied by the piston speed. From this result deductions due to clearance losses and heat expansion must be made to arrive at the actual volume of air delivered. These losses necessarily vary according to the style of the machine. emphasizing the inevitable conclusion that greater initial investment pays a handsomer dividend.

Beyond an arbitrary limit, however, compressor ratings at high speeds mean nothing but deception, since greater displacement than the air valve area permits is not possible, even if structural strength and bearing surfaces are adequate, which they rarely are. Experienced compressor users realize thoroughly the desirability of providing machines of size sufficient to deliver the requisite yield at moderate working speed, reducing cost of maintenance and greatly prolonging the life of the machine.

But while these recent prosperous times have enabled a great betterment of compressor equipment, there is much yet to be accomplished. There still remain air-brake pumps in use supplying shop requirements, and plants with compressors inadequate or obsolete, or both, are still altogether too numerous. An investigation applied to individual conditions would develop results so surprising as to overcome all ordinary objections to the increased investment, and instances where compressors have been shown to earn their cost within one to two years after installation are by no means rare.

For railroad shops and industrial establishments the steam-driven compressor is, of course, most generally employed, though many more motor-driven compressors are used than formerly, conditions being favorable. The demand is steadily growing for compressors of moderate capacity for use where steam to drive them is not available. Motor-driven compressors meet this requirement if electrical current is obtainable and gasoline engine driven compressors where neither steam nor electricity may be had. Such machines are highly useful for maintenance of way and bridge construction and for repairs at junction points. The necessity of testing the air-brake equipment of cars received from other lines has also created a considerable demand for self-contained gasoline driven compressors with engine and compressor mounted upon one bed, the engine driving the compressor by gear or silent chain.

Compressors up to 200 cubic feet per minute capacity for a terminal air pressure of 100 pounds per square inch are usually of the single-cylinder type, double acting. Above 200 cubic feet per minute two-stage compressors show an economy that should not be disregarded. Formerly duplex compressors having two simple compressing cylinders were common, but except for low-air pressures, which

do not warrant compounding, these have been superseded by the two-stage type.

The power saving effected through two-stage compression is illustrated in the subjoined table showing the horse-power required to compress 100 cubic feet of free air per minute from atmospheric pressure to the various pressures stated:

Gauge Pressure Pounds	One-stage Compression D. H. P.	Gauge Pressure Pounds	Two-stage Compression D. H. P.
10	3.60	60	11.70
15	5.03	80	13.70
20	6.28	100	15.40
25	7.42	200	21.20
30	8.47	300	24.50
35	9.42	400	27.70
40	10.30	500	29.75
45	11.14	600	31.70
50	11.90	700	33.50
55	12.67	800	34.90
60	13.41	900	36.30
70	14.72	1000	37.80
80	15.94	1200	39.70
90	17.06	1600	43.00
100	18.15	2000	45.50

The above table does not take into consideration jacket-cooling or friction of machine. Initial temperature of air at beginning of each compression is 60 degrees.

Steam cylinders are compounded generally when the steam pressure at throttle is sufficient to warrant. The limit of capacity at which the Corliss steam end should supplant the slide valve varies according to the appropriation available and the cost of fuel. Corliss compressors of 1,500 and 2,000 cubic feet per minute capacity are much more frequently installed than formerly.

After determining the important element of compressor selection, much can be accomplished in the direction of intelligent installation. Proper compressor location, a well-planned air-pipe system of adequate proportions, appropriate size and location of air receivers, provision for moisture drainage, systematic inspection to locate and stop air leakage, air hose of good quality, tight, quick-acting couplings, are all features which contribute to ultimate efficiency.

Since the atmosphere that we breathe is *free*, its value when compressed, represented by the cost of maintenance of plant and power expended in compressing it, is too lightly regarded, with the result that it becomes a favorite means of blowing dust from machines, work benches and garments, and a plaything in the hands of the mischievous, frequently with dangerous and sometimes with fatal results. For cleaning armatures and delicate machinery compressed air is often an indispensable agent, but strict orders and severe penalties should prevent its indiscriminate and unauthorized waste.

Trouble from the presence of moisture in compressed air is now infrequent, and is readily avoided by effectual cooling after compression, similar to the treatment provided for switch and signal installations.

Dirt and grit in compressed air clogs the necessarily delicate working parts of pneumatic tools and the inevitable excessive wear on valves and other parts causes rapid deprecation in value and power. To avoid this it is desirable to screen or filter the air at the compressor intake, but care must be observed not to have the screen of too fine a mesh or the air supply will become partially throttled. Occasional instances have occurred where compressor capacity has been markedly curtailed from this cause. As most of the air tools now sold are also provided with individual strainers, trouble from dirt in the tools is not frequent. These strainers also must be kept clean or the tool will appear to have lost its power.

The lubrication of compressors and pneumatic tools is a feature deserving careful attention. A too frequent mistake is made by using in air cylinders of compressors oil intended for steam cylinders. Such oil is of low flash point, whereas, the power lubrication of air cylinders demands a light oil of high-flash point and of very best quality. Oil of poor grade and low-flash point becomes vaporized in air cylinders and is discharged with the air without effecting lubrication.

Oil should be fed to air cylinders slowly and sparingly, as too much oil will clog the air valves, causing them to stick and give trouble. Air valves should be examined and cleaned at intervals by washing in kerosene or naphtha. When this is done the valves should be removed from the compressor. Engineers have been known to introduce kerosene through the air-inlet pipe, an effective method of cleansing dirty valves, but sometimes equally effective in producing an explosion, since the oil forms a fine spray or mist which, when compressed with the air, produces a condition similar to that in the cylinder of an oil engine.

The plan of feeding soap suds into the air cylinder through the lubricator is excellent for keeping valves clean, but when this is done oil should be fed through afterward to prevent rust.

The lubrication of pneumatic tools is of equal importance. One cannot do better than obtain and use one of the several brands of oil furnished by pneumatic tool makers who have made a special study of the requirements. Such oil is necessarily light, and under no circumstances should a heavy oil be used, as the cooling effect of the expanding air would cause it to clog the tool parts and prevent the free movement of the parts.

Pneumatic hammers should be carefully cleaned after using and kept submerged in a tank of oil when not in service. An excellent device for effectively lubricating pneumatic tools is an automatic oiler inserted in the supply hose about twenty inches from the tool, with oil-proof hose between oiler and tool, which, operating on the principle of an atomizer, enables the flow of the lubricant to be regulated to a nicety.

Unlike electricity, compressed air has worked out its own destiny in the hands of practical men, unaided by special technical courses at institutions of learning, and the results accomplished, as represented by the important position it now occupies, are the final word in behalf of this highly useful power.

POWDER IN BLASTING

Powder is an important item of expense in a mine, and much of it is generally wasted. Lack of facilities or wilful neglect in thawing frozen powder cause the inefficiency of much that is used. When frozen its rock-breaking force is much diminished, and it is vastly more dangerous to handle. Miners will often take a stick of giant powder frozen as hard as a rock and break it in two with their hands. It can be safely thawed by placing in tubes and standing in water heated to the right temperature. If there is no other means of thawing it handy, sit on it a bit.

Don't use too much powder in charging. Holes are often charged to the collar; a good miner, one who breaks the most rock, will charge his holes only about one-half, and a hole thus loaded will "break" as well and with much less gas than when loaded to the collar. The gases generated by the powder are rightly dreaded by the miners, and this excessive generation of gas is about the only additional result obtained by ramming a hole full of powder, or, as is common, by tamping it with powder.

There is some question whether the primer should be put in first in the bottom, in the middle, last, or where. It is really immaterial, for it will explode the powder as well in the bottom as in the middle. It might be possibly safer to put in the primer last, as it would not then be subject to so much tamping, but with an inferior quality of fuse, there might be less chance of a "burnt hole" if it were put in the bottom. In wet holes, to avoid misfire, it is best, even after having well greased the primer, to put it in last.

If a stick of powder is more than is needed, it should be cut in two with a knife, not broken. While the use of too long a fuse is not to be especially censured, the excessive use of powder, besides being wasteful, is the cause of many a "powder headache," and has caused more serious consequences, due to the gases thus generated, where there is a poor circulation of air.

TOUGHER THAN ELECTRIC DRILLS

Electric drills will be used in the development of the West Hecla group at Burke, Idaho. The machinery has been ordered. The power will be furnished by the Washington Water Power Company, a line being run from the station at the Hecla mine.—*Mining Review.*

The drills here referred to are as different as possible from electric drills, being in fact Electric Air drills. The first one, already successfully at work, was sent forward by express and on the way was dumped into the river. The motor was thoroughly water-soaked and filled with coarse white sand, a lot of water got into the air cylinders and one or two small parts had to be replaced. The report from the mine was that "after drying out the motor we took it up to the mine, and upon connecting it found that it started off without a hitch."

When speaking of these drills, it is quite important to remember the air, which is the only actuating agent in the drill itself and entirely transforms it from the discredited electric drill.

THE "SAND HOGS"

The following interesting story from a Philadelphia daily contains a variety of information, some of which our readers will accept as familiar, while other portions will be news to them:

"Men engaged in caisson work are veritable human soda water fountains," remarked the contractor.

Yet a pressure of thirty pounds to the square inch is not the limit. A pressure of fifty pounds is often applied. Industrial ambition does not even end there. It is proposed to test man's resistance to a pressure of 100 pounds to determine the feasibility of an attempt to tunnel beneath ocean waters.

Every man who sticks to the work, a contractor says, is broken down sooner or later. Many of the deaths are attributed in the physicians' reports to other diseases, but it was the compressed air, doubtless, that aggravated, perhaps caused, the diseases. Although it is not a matter of common knowledge, this great danger of working in compressed air is well known to the "sand hogs" themselves. It doesn't alarm them.

"Why do they stay in the business?" was asked.

"The money is what holds them," he explained. "A day laborer usually makes $1.50 to $1.75 a day. These caisson workers, who are fitted only for laboring jobs, get $3 to $4 a day, according to the amount of pressure they work in."

But it is not entirely the danger which determines the "sand hogs'" wages. Mr. Hollingsworth avers that of fully as great consideration is the fact that a "sand hog" does twice as much work as an outside laborer—*the compressed air in his system makes him feel so strong that he cannot work slowly.*

Eighteen "sand hogs" are employed on the Rapid Transit Company's caisson. Six work at a time, and the day is divided into three eight-hour shifts. For eight hours, excepting a half hour for lunch, a workman breathes only air which is forced into his lungs at a pressure of ten to fifty—usually about thirty—pounds to the square inch.

Of the 20,000 men employed in the work in various parts of the country, only about 5000 are professional "sand hogs," so that the ranks must be recruited constantly from green hands. An applicant is carefully examined by a physician, and if he has weak heart or lungs, or suffers from any chronic ailment, he is rejected. Those accepted enter the caisson at their own risk. Despite careful examination, a constitutional defect undiscovered by the physician often results in death.

To avoid laying the foundation of its proposed coaling station on quicksand, the Philadelphia Rapid Transit Company was compelled to sink two caissons down to rock bottom, forty feet below the surface of the ground and twenty-five feet below the bed of the Delaware. Upon them concrete corner foundations will be built. A box the dimensions of the foundation—in this case 22 by 32 feet—is built of Georgia pine planks laid over one another to a thickness of two and one-half feet, and made watertight by caulking. The height of the box is eight feet. Inverted, the box is sunk to the bottom. From two circular holes in its roof iron stacks rise upward. In the box all is airtight, and would be dark but for the electric lights provided.

As the hole sinks deeper in the sand of the river bed sections are added to the stacks, and the caisson box continues going lower as the excavation progresses. At a depth of thirty to forty feet the operations are most interesting, because then the battle between compressed air and river pressure—with human beings between the two forces—is at its height. Air is compressed in an engine house nearby and fed to the caisson through the two stacks. One stack is for freight, the other for passengers.

Calculating always on twice as much air pressure as the head of water—this to keep the water back while "sand hogs" burrow deeper into the ground—one who now enters that hole is subjected to thirty pounds of air pressure to the square inch of his body.

You climb a ladder to the top of the passenger stack, and the operative pulls a heavy lid up to let you in. You find yourself on a platform; the lid is closed over you. Two little candles flicker away at your feet to aid your courage. This, the guide tells you, is the critical stage—it is here that you are to be charged with compressed air. A valve is opened in the platform beneath you, and "siz-z-z" the air comes up and gradually envelops you. It condenses the other air to a fog. A roaring, like that of distant waters, is in your ears; then total deafness; then a feeling as though your jaws were locking and your throat drying to

crisp—which is overcome as soon as you succeed in swallowing—and then you feel all right—if you have not already collapsed.

It took three minutes to charge you; it seemed fully three hours. This had to be done gradually, or you could not have stood it with all your good constitution.

A lid is raised from the compartment under you; you descend a ladder to the sand bottom where six men are digging and shoveling away with a merry will. You are told that this quicksand would swallow you in a half hour but for the compressed air, *which hardens it so that it can be worked in.*

Returning, you must wait in that upper chamber until the compressed air is gradually drawn from you—an operation much slower than that of charging you. What if one should come immediately into the outer air? The "bends."

Dr. Hill and Professor MacLeod, two New York experts, believe it will prove practicable to go 200 feet below water level, and to use air pressure of more than 100 pounds to the square inch, if picked men are employed and if two hours are devoted to the liberating stage.

He who succumbs to heart failure usually drops dead in the caisson. Gruesome spectacle for his fellow-workers, yes; but they think of that $3 a day and keep on working. Sometimes it is only paralysis, and this may possibly be cured by "frying out" the victim—that is, *by placing him in almost boiling water for an hour or two.*

USES OF COMPRESSED AIR IN A SHIPYARD

Mr. James L. Twaddell, speaking before the Northeast Institution of Engineers and Shipbuilders, mentioned some of the incidental and unfamiliar uses of compressed air, as follows:

We have had a compressed air wood deck caulking machine, and we are now caulking a ship's teak deck with it, and it is doing excellent work. As compared with the ordinary style of hand caulking, we find—to put the case very fairly indeed—that in the hands of one man it does the work of four easily, but in many cases we have had far more than that out of it. In regard to the wood deck planing machine, that also emanated from our works, and it is a complete success. It is a much better machine than the electrical one, and the exhaust air clears its own track by blowing away the chips from the deck. As compared with handwork, there is no comparison at all. With the pneumatic machine you get a surface almost like that of a billiard table, whereas you get no regularity with hand-planing unless you go over it many times.

We have used pneumatic tools for distributing ground cork on the surfaces of war vessels, and also in covering the cork surfaces with paint, which takes a very great deal of hand labor when done with the brush. By distributing it with the compressed air the paint is put right into the rough surface with one coat, and the compressed air device does not use any more paint. It is a simple contrivance, something like an ejector.

We have found in many instances that compressed air can be used instead of steam. For instance, we have had lying at our finishing jetty a vessel with auxiliary machinery on board, but no steam near. We have applied the pneumatic power to auxiliary pumps, simply coupling up the compressed air and using it instead of steam. By this means we have also run an electrical plant all night. I mention this only to show the various uses that compressed air can be put to. In fact, the more I see of its usefulness the more I am surprised it has been so long in coming, and that so few have taken it up now it has come. I consider the adoption of pneumatic plant in shipbuilding yards one of the finest things that has happened during the last ten or fifteen years in shipbuilding. It is a matter of such wide interest that people have only got to see it to be convinced of its utility.

COMPRESSED AIR IN IRON FOUNDRY

Compressed air is now used in the large iron foundry at the Schenectady works of the General Electric Company for almost every operation connected with the making of a finished casting. Although the machinery in the other adjacent shops is operated entirely by electricity, in the iron foundry, where the operations are scattered and intermittent, compressed air was found to be advantageous for small power services. The air is supplied at 80 lbs. pressure by a number of electric motor-driven compressors of different capacities.

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W. L. SAUNDERS, M. Am. Soc. C. E., . Editor
FRANK RICHARDS, Mem. A. S. M. E., Managing Editor
L. I. WIGHTMAN, E. E., - - Business Manager

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COMPRESSED AIR TO MAKE SHIPS SAFE

A writer in a recent issue of the *Scientific American* offers an important suggestion concerning the saving of ships by the use of air, arguing that provision should be made for it in the design and construction of steel vessels generally. No radical changes and no heavy outlays would be involved. He writes:

"I would suggest, in the first place, that the main deck or first deck above the load waterline of every passenger steamship, battleship, and cruiser should be built airtight, and of sufficient strength to sustain a pressure of air below that deck that would keep the vessel afloat, even if the bottom were perforated in every compartment. That would mean, of course, that the deck would have to be so built that every opening could be hermetically sealed, so to speak, and in the shortest possible time. Each compartment should be separate and independent of the other. Each of the compartments should have an airlock, on the same principle as those used in the construction of the North and East River tunnels in New York City. A gang of locomotive airbrake pumps should be installed above the safety deck, operated by gasoline motors, so that they would be wholly independent of the ship's power—of sufficient capacity to fill any one or all the compartments with air within a short space of time. By these means, easy and safe access could be obtained to any compartment, and repairs made to the damaged part of the vessel. Further, each one of the compartments should be supplied with an electric light system and a telephone system, controlled and operated from a central point. A vessel equipped in this manner would be practically unsinkable, unless broken in two or the plates strained in every part of the ship so that the air pressure could not be maintained; and even in the former case, if each half of the vessel had its full complement of air pumps and other appliances, the two halves could be kept afloat independently, but, of course, the propelling power would be available only in one portion. The additional expense entailed by this mode of construction would be comparatively small.

"Take the case of the Allan steamship *Bavarian*, recently floated in the St. Lawrence River by means of pneumatic pressure. The cost of the vessel was over $1,000,000. She was sold by the underwriters, I understand, for about $30,000. That amount, I estimate, would fully cover the cost of installing the appliances I have suggested herein; but assuming it would be $100,000, it would be well worth expending to insure the safety of a vessel of that class. No vessel, large or small, that traverses the ocean is immune from danger by striking derelicts, icebergs, collision with other vessels, or running aground in foggy weather or in heavy snowstorms, when lights are obscured and the reckoning can not be ascertained, in approaching a dangerous coast.

"Provision should also be made for the installation of check valves, relief valves, and air gauges both inside and outside of each compartment, in order that persons working under air pressure could regulate the supply of air as circumstances might require. It would appear to me that sliding doors should be used, instead of swinging doors, in all partitions below the airtight deck, and that these doors should be kept closed except when not actually in use, and that horizontal sliding doors

should be used to close apertures or hatches in the safety deck. A system of indicators might be installed in the central telephone and electric light switchboard room which would show, at all times, the position of the vertical and horizontal doors in each compartment; that is, whether they were open or closed. I have not gone into any calculations with regard to the air pressure that would require to be developed, but I would estimate, roughly, that it would be very much below 30 pounds to the square inch."

The writer evidently is not fully informed, and does not claim to be, as to the details of modern marine construction or of general engineering practice. The suggestion as to the employment of air-brake pumps is, of course, absurd. There are gasoline-operated single-stage air compressors which would be very suitable for this service. They would not be bulky or costly, would be always ready and would work with reasonable economy.

It will be remembered that the January, 1907, issue of COMPRESSED AIR contained a graphic description of the raising of the *Bavarian*, above referred to.

COMPRESSED AIR FOR REFRIGERATION.

Mr. Sydney F. Walker, Bloomfield Crescent, Bath, England, contributes to *The Engineering and Mining Journal* an interesting and valuable article upon the "Mechanical Production of Low Temperatures," discussing the principles of refrigerating processes which may be used for cooling deep workings and in shaft sinking by freezing.

The use of the freezing process, he says, for sinking shafts is steadily increasing, and the problem of the increased heat at the continually increasing depths to which both coal and metalliferous mines are being sunk is gradually rendering the problem of the mechanical production of low temperatures of increasing interest. Refrigeration and the artificial production of ice have been in vogue for about twenty-five years. Broadly stated, the mechanical production of low temperatures is dependent upon the ability to convert certain substances from the gaseous to the liquid state, and their return to the gaseous state, by the abstraction of heat from the substances to be cooled. The process consists practically in abstracting the heat from the substance that is to be cooled, and transporting it to the cooling water of the condensing plant.

There are three substances now employed that can be converted from the gaseous to the liquid state, and *vice versa,* with comparative ease, viz., ammonia, carbonic acid and sulphurous acid. Other substances have been employed. Ether, for instance, was employed somewhat largely in the early days of mechanical refrigeration, and is still to a certain extent in India, owing principally to the very low pressures required. Compressed air has also been employed, and is still to a certain limited extent, but compressed air is very much less efficient than either of the other refrigerants named, mainly because, owing to the large power required, no attempt is made to liquefy it. It is merely compressed to a certain pressure, cooled, dried, and allowed to expand.

Probably compressed air will be found to be the readiest agent for dealing with the high temperatures met with at great depths in mines, since the whole apparatus can be installed underground, and run by an electric motor.

In view of the possibility of compressed air being used for lowering the temperature in the workings of deep mines, or for similar purposes about a mine, it may be useful to shortly describe the apparatus. It consists of the usual air-compressing cylinder, with its reciprocating piston, and an expanding cylinder, which also has a reciprocating piston, the two pistons being connected to the same crank shaft, their cranks being usually 90 deg. apart.

Cooling and drying apparatus of various forms completes the plant. One form consists of a cylinder, nearly filled with glass marbles. A fine spray of water is delivered to the top of the mass of marbles, and gradually trickles down over them, passing through the interstices between them, and the air to be cooled enters the cylinders at the bottom, passing up over the surfaces of the marbles, meeting the spray of water, and being cooled and depositing its moisture.

From the cooling cylinder, the air passes into the expanding cylinder, where it works the reciprocating piston, the work performed upon this piston going to assist the work of the engine or motor driving the compressor, the motor thus having only to supply the difference between the two.

In the expanding cylinder the air is cooled

to whatever temperature may be desired. It is claimed by makers that it is cooled to as much as 100 deg. below the freezing point. From the expanding cylinder, the cooled and expanded air is driven into the chamber or other place to be cooled, and in regular cold-storage work is usually drawn off again by means of a duct, provided for the purpose, to the compressor, recompressed, recooled, expanded, and so on.

The great source of loss, quite apart from the inefficiency of the method of compressing and expanding the air, is that by conduction through the walls of the pipe, or duct, through which the cooled air passes to the chamber or object to be cooled. This duct is made as short as possible, and it is also well insulated thermally, but in spite of that, considerable loss too often results.

Another method is that employed in the Allen dense-air machine, made by H. B. Roelker, of New York. In this apparatus there are two important points of difference from that previously described. The air, after being cooled, is carried in small pipes into the space to be cooled, much in the same way as the ordinary refrigerating agent, ammonia or carbonic acid, is, and it is brought back, after circulating through the grid of pipes, to the compressor, the grid of pipes in which the air circulates corresponding to the expansion coils of the ordinary compression or absorption apparatus.

In addition, the air is cooled on leaving the compressor, by being passed through a coil of copper tube, immersed in a cylinder, through which water is kept circulating. Further, the return air from the chamber that has been cooled is caused to cool the air on its passage from the cooling coil to the expansion cylinder, by circulating in pipes round which the air from the compressor passes, the arrangement being similar to that employed with cooling water and steam in the surface steam condenser. The apparatus has also an auxiliary air compressor, consisting of a small cylinder with piston and auxiliaries, the object of the arrangement being to charge up the system, when it is first put into service. The air, it will be understood, circulates continually round and round, through the compressor, the copper cooling coil, the returning air cooler, the expansion cylinder, the cooling coils, back to the compressor again, any loss being made up, when required, by the auxiliary compressor.

This apparatus appears to be very suitable for cooling the workings of deep mines, since the air-cooling pipes could be carried into the workings, and arranged in any convenient manner. One difficulty that will present itself to mining engineers is the possibility of breakage of the pipes. This could probably be overcome by the employment of flexible metallic tubes, either wholly or for connecting straight lengths of ordinary iron pipe.

FATAL EXPLOSION OF A MINE LOCOMOTIVE

A compressed air locomotive exploded with fatal effect on June 4 in Colliery No. 14 of the Pennsylvania Coal Company, near Scranton, Pa. The locomotive was drawing its last trip of cars for the day to the shaft. The pressure of air was low and a charging station being reached a little over half a mile from the shaft air was taken in at that point. The pressure in the tanks is stated to have fallen to about 200 pounds, while the permitted tank pressure was 600 pounds, a pop safety valve being set at that pressure. The pressure on the pipe line was 1000 pounds and when the gage on the locomotive showed 550 pounds and while the brakeman who did the charging was in the act of closing the valve the explosion occurred. Of the twin tanks on the locomotives one was broken mostly into small pieces. The other tank had one head and the end cylindrical section blown off, and the side of the tank was ripped. Many bolts and rivets were sheared as if by a machine. The metal all seemed to be perfect, and it was said that there was no sign of fire or of oil on the metal.

The locomotive driver and another man were killed instantly, and a third died soon after, while a number were severely injured.

In expressing some opinion as to the cause of this terrible and unusual accident we of course speak only tentatively and in the light of present information, which of course is not sufficient to warrant a final or authoritative determination.

From the force and the disastrous results of this explosion as narrated, it seems to us evident that it was not due to an excessive pressure of air or to the weakness of any part of the apparatus. We would say that it was undoubtedly due to the formation of an explosive mixture of air and oily vapor and then a

sufficient temperature *at some spot* to cause ignition.

Although we have no record of an explosion quite similar to this, there is always a possibility of danger in the *rapid* recharging of an apparatus of this character. In this case the pressure was raised quite suddenly from 200 to 550 pounds. Neither figure may be the limit. In the body of either tank we may suppose that the incoming air mingled with that already in it with some rise of temperature but not enough to be dangerous in itself. Any portion of the original charge, however, remaining in any pipe, passage or pocket would not be mixed with the incoming air, but would simply be compressed from the lower to the higher pressure, and its temperature would be raised correspondingly, just the same as if it were compressed by a piston in a cylinder. If the temperature of the air at 200 pounds was 60 degrees its temperature at 550 pounds would be 233 degrees, which probably also could not be considered dangerous, although approaching the danger point.

As the last trip was being made and a number of men carried on the train were probably clamorous to get out, we may suppose that the recharging was done as rapidly as possible. The inrushing air was therefore heated by friction to a temperature not computable but evidently sufficient, in addition to the heat above stated for the compression, to cause the ignition. The air in its inrush also must have traversed some passages where oil had accumulated and some of this oil was vaporized and mixed with the air, and then both the explosive mixture and the ignition temperature were provided for the fatal catastrophe. We may suppose that the explosion when it did occur was of a mixed character. The explosive mixture did not fill both tanks, and probably only a portion of one of them, but its ignition began the work and probably did most of the damage, the suddenly released air which was not ignited following up with its tearing force until the pressure was gone.

EXPLOSION OF AIR RECEIVER

A vertical air receiver, 40 inches diameter and 10 feet high, recently exploded in the works of the Northwestern Thresher Company, Stillwater, Minn. The working air pressure was 100 pounds, and presumably this was the pressure when the explosion occurred. The seam connecting the lower head with the shell let go and the body of the receiver was thrown up against the roof, breaking two wood rafters 3" x 14" and cracking a 12" x 12" beam. A hole was knocked in the masonry foundation and two men were injured, one having been thrown upon a vise and the other against a planer.

This seems to have been a simple explosion, due to weakness at the point where the rupture occurred. Whether an excessive pressure was reached or whether the receiver had been locally weakened is not known. It is proper to call attention to the fact that the condition of the lower part of a receiver of this style, where water slowly but constantly accumulates and is occasionally drawn off, the surfaces being alternately wet and dry, is precisely that most promotive of rust. For the weakening of a receiver from this cause the makers cannot of course be held responsible. Receivers should be inspected and tested from time to time. Protective paint is often used outside, but it is really more needed inside.

COMPRESSED AIR IN COTTON INDUSTRIES

Compressed air as a power transmitter has always shown a remarkable faculty for finding new lines of employment for itself. When once installed for almost any purpose its use soon spreads to other convenient, economical and labor-saving applications. A little pamphlet recently issued by the Ingersoll-Rand Company, 11 Broadway, New York, *Some Economical Applications of Compressed Air in the Cotton Industries,* tells of some of these later adaptations.

One of the most important advantages of compressed air for this service is the fact that it is absolutely safe. There is no possibility of starting a fire with it; no danger of fiery "short circuits" or sparking motors; no possible damage to be done by a broken line; no danger to the mill operators. It is a clean power, and its discharge, anywhere, improves the quality of the atmosphere in that place. It does not require a specialist to look after it and keep it in trim. It has a happy faculty of "delivering the goods" with the minimum of care, attention and cost.

In cotton mills it has always been a problem to keep the machines, and particularly the looms, free from flying lint and dust. Collect-

ing upon and interfering with the operation of the machinery, it has been necessary, in the larger mills, to shut down at intervals, and clean by hand, thus involving a waste of time, a loss of product, an increased percentage of "seconds" and the services of a cleaner. The modern method directs a jet of compressed air against the foul parts of the machine, blowing off the accumulated lint. Ring rails and spindle rails may be perfectly cleaned in this manner.

By this means the machinery in an entire room may be cleaned in a very few minutes without shutting down, and a better job will be done than is possible by hand; in fact, two men with an air jet can do the work of ten or twelve by the old slow method, besides saving the time and product formerly lost by the shutdown, and by the decreased amount of "seconds" produced. This little kink is saving time and money in some of the largest cotton mills in the country.

Compressed air can also be advantageously employed in cotton-seed oil mills for cleaning crushing rolls and separator plates. In an average sized mill it formerly took four men, working five hours each day, to clean these parts, the machine, of course, having to be shut down during the process. With compressed air, however, one man can do this work and do it more thoroughly.

Other applications of compressed air to these industries are almost too numerous to mention, it being possible to employ pneumatic motors, hoists, tools, displacement pumps and air-lift pumps to great advantage, the absolute safety of compressed air making it the ideal motive power for use in these plants.

The Cutler Hammer Company, of Milwaukee, announce the purchase of the Wirt Electric Company, of Philadelphia. The manufacture of the Wirt apparatus will be continued, and the current Wirt catalogue will apply for the present.

Baltimore has abandoned its municipal lighting plant because a private company offered to supply the same illumination at one-fourth the city's cost. And the two American Dreadnought contracts have just been awarded to private bidders because they underbid the navy yards, although the private bidders reckoned upon a profit and the navy yards estimated at cost.

WATER POWERS.

The following is from a lecture by Prof. John Harisberger to the class in Power Transmission, University of Washington (State):

Realization of profitable commercial and industrial conditions depends very largely on the possibility of obtaining cheap motive power, and the cheapest known power is that derived from natural waterfalls, which is energy coming nearest to being perpetual motion, having practical value, to be found on this globe.

In the transformation and transmission of this power into such shape that it can be applied to do useful work in localities where work to be done is desired, loss of power occurs. To keep this loss to a minimum is necessary for satisfactory commercial results. This is a problem for the engineer.

Taking for granted that a location has been found where water power can be developed and data as to preliminary work, regarding approximate fall and amount of water available, has been secured, the next step will be to check this data of preliminary work by taking accurate measurements of the flow of water in the stream for several months, desirably during the low-water season. If the elevation of the power site is 2000 feet or over, the supply of water for streams will be derived mostly from glaciers and melting snow, and the low-water season will be in the winter months; while with a power site nearer sea-level, the stream being fed by rain, springs, and melting snow in the foothills, the low-water season will be during the summer months. This is especially the case in the Northwest.

The watershed of the stream should be explored to ascertain the nature of the country drained, especially as to forests, and find out if the forests are private property or in the government reserve. Heavy forests on the watershed are of material value from a water-power standpoint, as they tend to regulate the rate of discharge of the stream. Their sponge-like property has the effect of retarding the flow of water to stream, and snow falling during the winter is protected from the sun by the trees, which is the cause of the gradual discharge of the stream instead of a spasmodic flow, as will be the case if the watershed be barren of trees. From this it is evident that it is desirable that forests in basins, at elevation below 3000 feet, drained by streams utilized for power purposes, be in the government

reserve, for if they are private property it will only be a question of a short time when the trees will be cut down, thus destroying *one of the best and cheapest power storages we have.*

In the past it has been, and even now is, the practice to build the power-house of no greater capacity than the power of the stream at low-water flow, in which case at least seventy-five per cent. of the power available goes to waste by the water flowing to lower level without doing any useful work. Ideal conditions are seldom found as to watershed in its natural state, so that the flow of the stream is uniform the year around, so artificial means must be employed for the storage of the water that the entire flow off of the stream the year around can be utilized. If this can be done, a power-house of at least the capacity of average power of stream should be built.

Having obtained measurements giving hydrostatic head and flow of water, and knowing what the practical possibilities are for storage of water, the capacity of power-house that should be built can easily be determined by the following formula: Horse-power equals .1134 times cubic second feet times head times 71 per cent.

If an electric generator is employed, say for long-distance transmission, this gives the power at the switchboard, allowing for losses in pressure pipe, water wheels and generators, or about seventy-one per cent. of the power, which is about as good as can be obtained with apparatus available and average power sites. Many conditions must be considered when establishing location for intake and power-house. The possibility of back water interfering with the operation of the water wheels, which may be caused by floods occurring only about once in ten years should not be overlooked.

The shortest possible length of pressure pipe between intake and water wheels for a given head is desirable for good speed regulation with economical use of water. Satisfactory regulation is impossible when a long pipe line is used for a low water plant, and it is attempted to vary the velocity of the water in the pipe for speed regulation.

In high head plants, where the velocity of the water is kept constant in the pipe, governing being done by diverting part of the water from the runner of the water wheel, the question of length of pipe line will only be a matter of cost, and convenient locations for intake and power-house. The intake for pressure pipes should, if possible, be a storage basin of comparatively large area, so velocity of water will be very low, thus allowing any grit or sand to settle to the bottom. This basin should have a sluice gate, so sediment can be sluiced out occasionally without going down pressure pipes and through water wheels. Sand and grit are very detrimental to the life of water wheel runners, as well as the water wheel housing and pipe line, and every means should be employed to eliminate any sand from the water that is to come in contact with the water wheels. The higher the head the more important this is.

FOR A TRAINING COAL MINE

At the summer meeting of the Coal Mining Institute of America, held recently at Pittsburgh, President F. C. Keighley delivered an interesting and suggestive address from which we take the following:

There is not a vestige of a reason for the non-existence of such an institution as a training coal mine, any more so than a few years ago there was for the absence of a correspondence school of mines. The army has its West Point, the navy its Annapolis and training ships. The railroads send out their model airbrake and other cars in order that their men may be trained in those lines; even the United States Department of Agriculture sends out a car exhibiting the works of model farms to the farmers of every railroad community. The colleges of to-day have their machine, electric, carpenter, and other shops, foundries and laboratories. Manual training and model factories for facilitating it are to-day recognized as not only good things, but the proper and necessary fountain-heads for the issuance of a stream of skilled labor that is being clamored for the length and breadth of this great land; yet no place exists to-day where a young man who desires to make mining his life work can familiarize himself with systems, methods and practices, as he would be able to do in a model coal mine or training mine; call it what you will so that it may be given life. If the State of Pennsylvania is too poor to set the example, let some other State do it. If some other State should be first to take action, it would be to the eternal shame of the greatest coal producing State in the world, and of the wielder of a twenty-million dollar pen holder

that is now writing messages of scorn for the taxpayers of the great State and the death warrants, as it were, of political thieves—and will continue to do so for some time to come.

The establishment of a model coal mine for the training of coal miners will save the great State of Pennsylvania so many millions of tons of black diamonds in the next decade that it can afford to forget the extravagance of flaunting before the world a twenty million dollar pen holder (the real value of which is not one-fourth that sum) as soon as the said pen holder has gotten through signing the death warrants of political jobbers. If this model mine cannot be tolerated as a business proposition, let it be one of charity—a place where the miner's orphaned boy can find a schooling and a home. There are many scores of men in this land that have each made money enough from coal lands and coal mining alone to enable them to not only donate or lease the coal land on a low royalty for such a purpose, but to provide such a mine without serious drain on their spending money or resources. Some man will do it some day, and at the same time do his nation so great a service that his name will rank high in the annals of the illustrious of this land.

THE OXY-ACETYLENE FLAME FOR STEEL CUTTING

The Davis Bournonville Acetylene Development Company of New York City, on June 13, under the western approach of the Williamsburg Bridge, gave a demonstration of steel cutting with an oxy-acetylene blowpipe flame, the operations being under the direction of the inventor of the torch and vice-president of the company, Eugene Bournonville.

The 6 in. side of a 6 x 4 x 5/8 in. angle was cut through in 1½ min. A plate 3/8 in. thick was cut into for a distance of 3 ft. 2 in. in 9 min. 36 sec. A 5 ft. built up I beam girder, consisting of a 3/8 in. plate for the web and four 6 x 4 x 5/8 in. angles at the edges, was practically cut through in 31 min. A 6 x 4 x 5/8 in. angle was completely severed in 2 min. 50 sec. In all of these tests there was used approximately 37 cu. ft. of oxygen and 18 cu. ft. of acetylene, at what pressure is not stated.

This process requires three tanks: one containing compressed acetylene, and the other two compressed oxygen, one of them at high pressure, in this case 900 lbs., although still higher would have been preferable. The low-pressure oxygen and the acetylene are first admitted to the blowpipe in proportions adjusted for proper combustion, and the flame is directed on the steel until the surface is well heated; then an additional jet of the high-pressure oxygen is passed through the torch and the "cutting" is really the direct burning of the steel in the path of the jet. The cut made is only about 1/8 in. wide, so that the loss of metal is not greater than in sawing or planing.

TROJAN NON-FREEZING POWDER

Trojan non-freezing powder, manufactured by the Independent Non-Freezing Powder Company, Allentown, Pa., is an explosive compound said to contain no nitro-glycerine or picric acid. It is claimed that the powder will not freeze and that on explosion no injurious fumes are given off. The powder is reported to have an explosive force equal to that of nitro-glycerine dynamite, and that in two years of practical rock-drilling tests the powder has met all requirements. It is put up in cartridge form and can be detonated by ordinary methods. One of the advantages claimed for the new explosive is that the absence of poisonous gases permits the workmen to return to their work immediately after blasting.

The Baldwin Locomotive Works has recently completed an order for twenty locomotives for a French railroad. These were all built to French drawings and specifications, with, of course, French or metric measures throughout. It would have been a strange thing if intelligent American workmen had not been able to work with perfect ease and accustomed accuracy to those measures as well as to any others. Of course there were special jigs, templets, gages, etc., required, but on the whole we may assume that the contract was remunerative or it would not have been undertaken. There may be in it a promise or a possibility of more contracts to come. If other manufacturers in other lines can get, at prices assuring profit, machinery to build to metric measures undoubtedly they will be glad enough to do it. Absolutely no legislation is required for it any more than law tinkering is required to enable German manufacturers to produce, as they do, building blocks to inch dimensions for American children.

THE WHISTLING BUOY

The whistler is the monster of the buoy family, sometimes reaching a height of over 36 feet and weighing three tons or more. Naturally, such enormous pieces of mechanism have to be handled very carefully in the sea, and the placing and removing of these buoys is a work of decided interest and some hazard, all the greater because a whistling buoy is never placed except where the water has some swell most of the time.

The buoy has a long tube projecting downward, a whistle on top and an air intake provided with a valve. When the buoy is placed, the tube fills with water. When a wave raises the buoy the water recedes in the tube and air comes into the bulb through the intake. When the wave passes and the buoy drops again, water is forced up the tube. The valve of the air intake pipe closes of its own accord from inside pressure, and the air compressed by the weight of the water thrust upward escapes through the whistle, making a sound of the most indescribable sadness and melancholy—weird and mournful in the last degree. So marked is this characteristic of the buoy that the Lighthouse Board has to weigh well the advisability of placing one of these buoys within earshot of near-by dwellings, because of the emphatic protests of the owners of property against the depressing influence of the sound.—*Yachting*.

AIR BRAKE AIR CONSUMPTION OF PASSENGER AND FREIGHT LOCOMOTIVES

Railway and Locomotive Engineering thus discusses the relative compressed air needs of passenger and of freight locomotives:

It might seem at first thought that the passenger locomotive could get along comfortably with a smaller pump than is required for the freight; a little reflection—and calculation—will show that a passenger train of ten moderately heavy cars requires as much air to operate its brakes as is required by a freight train of nearly four times the number.

The capacity of a 16 by 33 inch auxiliary reservoir is about 3,900 cubic inches, and that of an 8-inch freight auxiliary about 1,600 cubic inches, so that the passenger auxiliary has nearly three times the capacity of the freight.

To charge one of the 16 by 33 inch reservoirs to 110 pounds pressure requires about 29,250 cubic inches of free air, and to charge ten of them to this pressure requires 292,500 cubic inches.

To charge an 8-inch freight auxiliary to 70 pounds pressure requires approximately 8,000 cubic inches of free air, and from this it may be seen that the quantity of air required to charge the ten auxiliaries to 110 pounds pressure would be sufficient to charge 36 8-inch freight auxiliaries to 70 pounds pressure.

The capacity of a 16-inch by 42-inch reservoir, such as is used with the 16-inch brake cylinder, is about one-third greater than that used with the 14-inch brake cylinder. Hence, if the cars were equipped with 16-inch instead of 14-inch brake cylinders the air required to charge their reservoirs to 110 pounds pressure would be sufficient to charge forty-eight 8-inch auxiliaries to 70 pounds.

From the above it may be seen that the big pump on long passenger trains does not have to remain idle much of the time if stops are numerous.

In addition to supplying the brake system with air it must also take care of the air signal and the water raising systems, which make a slight additional demand not required of the freight engine's pump.

WORKING CONDITIONS FOR COAL CUTTERS

The following information concerning the conditions which make the employment of air-operated coal cutters profitable or otherwise is abstracted from a voluminous report to a British parliamentary committee:

"The mechanical cutting of coal has been in operation at collieries for a long time, being first introduced in the latter half of the last century, but it did not pass out of the experimental stage for many years.

"That the use of mechanical cutters has spread, and is extending in the coal mines of the United Kingdom, is demonstrated by the fact that, whereas in 1900 an output of 3,321,012 tons was obtained by the use of 311 machines, in 1905, the most recent year for which figures are available, the output had increased to 8,102,197 tons, produced by 946 machines.

"In the United States the use of mechanical coal cutters is much more advanced than in Great Britain; for instance, in 1905 there were no less than 9,184 machines working, producing 92,318,261 tons, and, comparing the amount of

coal produced in that country with the British output, it might be urged that the great increase in the former is due to the special adaptability of the seams to the use of coal cutters, but it is doubtful whether this alone will account for the greatly extended adoption of machine cutting in America.

"It may be mentioned that the great majority of the machines used in the collieries of the United States are those designed for the board and pillar system of working, whereas in Great Britain machines suited to the longwall method of working coal are most generally used, which method of mining is better adapted to the advantageous use of machinery for undercutting (holing or kirving) coal. This would seem to point to the fact that the advantage of machine mining in Britain is relatively greater, for the machine-worked seams in America are thick, and thick seams, most of the witnesses informed us, can be more profitably worked by manual labor. But thickness of seam is not the only governing factor in the economical application of mechanical coal cutters. The use of coal cutters is conditioned by:

(*a*) The character of the roof of the seam.
(*b*) The thickness of the seam.
(*c*) The nature of the coal.
(*d*) The inclination of the seam.
(*e*) The character of the floor of the seam.
(*f*) Geological disturbances.

"For example:

"(*a*) Where the roof is of such a character as to render close timbering necessary, and there is not sufficient room for the machine to traverse the face, or it is unsafe for it to do so, cutting by machinery is impossible.

"(*b*) A thin seam, by which is meant a seam of 3 feet or under, is, presuming the roof is good, and the coal sufficiently hard to stand for holing, more profitably under-cut by machinery than by hand, as the thinner the seam the greater the hewing price paid to the miners, also less small coal is made in holing by machine than by hand holing. On the other hand, in excessively thick seams, such as the thick coal of South Staffordshire and part of Warwickshire, it is impracticable to utilize coal-cutting machinery; the cut would not remain open, and the noise of the machine would introduce an element of danger, when at certain periods of mining operations quiet, as pointed out by Mr. Hughes, is very necessary. But, as shown by the report of the committee of the North of England Institute of Mining Engineers on Mechanical Coal-Cutting, there are numerous instances of machines at work with undoubted success in seams up to 6 feet in thickness.

"(*c*) Where the coal is excessively hard to hole (under-cut) and there are no other adverse conditions, it might be less costly to perform this work by mechanical cutters than by hand. But where a seam is of such a character that it will not stand for under-cutting, owing either to the softness of the coal or its liability to breaking away (South Yorkshire), or owing to the existence of joints in the coal (slips or backs), as in the case of the steam coal collieries of South Wales, or when the coal settles down behind the cutting machines and can not be kept up, mechanical coal cutting can not be resorted to.

"(*d*) When seams are highly inclined longwall coal-cutting machines can not be used (Swansea district and part of North Staffordshire).

"(*e*) When the floor of the seam is a bed of fireclay, it is frequently profitable to hole in it by machines. An evenly graded floor is a desideratum.

"(*f*) Successful mechanical coal-cutting is nearly always impossible in seams much intersected by faults or dykes, especially in collieries worked on the longwall system."

A FREE LABOR EXCHANGE FOR ITALIANS

During the fiscal year ending June 30, 1906, the number of Italian immigrants entering the United States was 273,100, a number greater than of any other nation. The number for the present year is much higher than this. The larger percentage of these are uneducated, cannot speak English and are so poor that they must have immediate employment. The so-called agents who have pretended to assist them have charged exorbitant fees, both to the laborers and to the employers.

Some American gentlemen last year decided to form an organization for the purpose of creating a free labor exchange, to act as an intermediary between those seeking employment and those who would employ them. These gentlemen are: Mr. Augustus Healy of New York; Mr. Giovanni P. Morosini, banker, of New York; the late Mr. Joseph Ratti, of

Bloomsburg, Pa.; Mr. Joseph Tuoti, and Mr. C. A. Aimone.

The office was opened in April, 1906, under the name of the "Labor Information Office for Italians," at its present address, No. 59 Lafayette St., New York City; and, although it threatened some rather powerful interests, from the date of its opening up to June, 1907, it had secured employment for 7,194 persons—of which number 2,493 were employed in the last five months. Also during this last period 319 employers made application for help, and 5,532 Italians were advised as to the conditions of work, wages, etc.

The office has still another aim, which is of national interest—the distribution of newcomers throughout the United States. It is well known that most of the Italians coming to this country settle in the large cities of the East; while they would be of much better use to their new fatherland if they would go to the Western and Southern agricultural regions.

The Italian laborer has become of vast importance in the industries with which the rock drill and the air compressor have to do, and employers in these and affiliated lines will do well to open communication with this exchange. G. di Palma-Castigliane, Manager, may be found or addressed at 59 Lafayette (formerly Elm) St., New York City.

A printed form has been prepared for employers asking the following questions:

Name and address? Kind of work and where? Permanent or temporary, and, if the latter, for how long? Number of men wanted? Hours of work? Rate of wages offered? Pay-days? Will transportation expenses be refunded? Is knowledge of English requisite? Do you provide medical attendance and at what rate? How long is this application good? Is there any strike or labor trouble? Correspondence might generally be expedited by answering these questions in the first communication.

NOTES

The address of the Fornham Sand Blast Company is 41 Park Row, New York City.

"Advertising in Reference Books" was the subject discussed at the May meeting of the Technical Publicity Association. At the first fall meeting of the Association in September the topic will be "The Mailing List."

The Automatic Air Compressor Company of Bridgeport, Conn., has filed a certificate of incorporation, the incorporators being John Rogers, E. F. Coleman and James A. Pease. The authorized capital is $50,000.

The exhibit of the Allis-Chalmers Company, Milwaukee, at the Jamestown Exposition, includes a portable air compressor built on the principle of the Christensen compressor. It is built for capacities of 11, 16, 20 and 50 cubic feet, and is furnished mounted on an ordinary four-wheel platform truck. It is adapted to use in small shops, where the need for compressed air does not warrant a large stationary compressor.

The William Tod Company, Youngstown, Ohio, is building for the new plant of the Indiana Steel Company, Gary, Ind., four horizontal cross compound steam blowing engines of large capacity, which will form an important part of the blast furnace equipment. These engines are 44 and 84 x 72 in.. with air cylinders 90 x 72 in. Each engine has a capacity of 50,000 cu. ft. of free air per minute.

The Piqua Blower Company of Piqua, Ohio is being incorporated under the laws of Ohio, with a capital of $50,000. This corporation will take over the interests of the Piqua Foundry and Machine Company of Piqua, Ohio, and will make a specialty of the manufacture of positive blowers and gas exhausters as developed by the latter company in the past two years. As the machinery of the latter firm has met with great success, it is necessary to effect this reorganization in order to take care of the large volume of business offered.

The Sprague Electric Company of New York City has opened a district office in the Hennen Building, New Orleans, which has been necessitated by the constantly increasing business in its various products in the southern territory. This office is under the management of Mr. F. V. L. Smith, lately Chief Inspector of the Louisiana Bureau of Fire Prevention, and will cover the territory included in the States of South Carolina, Florida, Alabama, Georgia, Tennessee, Mississippi, Louisiana, Arkansas, Texas, Oklahoma, and Indian Territory.

The Billings & Spencer Company, Hartford, Conn., has recently occupied its new machine shop, one of the finest in New England. The

building is 55 x 250 ft. with monitor roof over a crane bay, and broad galleries for the lighter machine work. A 20-ton Niles electric traveling crane serves the central bay, with a number of jib cranes for the heavy individual machine tools. Spacious elevators serve the galleries on each side. The water supply for the entire plant is supplied by Ingersoll-Rand compressors and the Air Lift.

The Independent Pneumatic Tool Company, Chicago, writes as follows: Our business since the first of the year has shown a remarkable increase over the corresponding period of last year. Although we have greatly enlarged our plant at Aurora, Ill., increasing our output 50 per cent., we are unable to meet the demand for our Thor Pneumatic Tools. Our plant is in full operation night and day, and we have sufficient orders to keep running for several months. Before the end of the year we expect to double our facilities. We are receiving a large number of orders for export.

In the erection of the 32-story building of the City Investing Company now in progress at Broadway and Cortlandt streets, New York, the ¾" and ⅞" rivets in the connections are driven by 16 four-man gangs, with Cleveland pneumatic hammers operated by pressure from two Clayton duplex air compressors lolated in the basement. These deliver to separate receivers, but a single 2½ inch vertical pipe from both receivers is run up near the center of the building with a 2 inch horizontal branch at each floor which runs to both ends of the building with 16 outlets for the air hose to the hammers.

In the erection of the Trust Company of America building, 41 Wall Street, the field rivets were driven at the rate of about 300 per day by each of eleven 4-men gangs, using Chicago pneumatic hammers operated by an Ingersoll-Rand steam driven compressor and a Chicago electrically driven compressor, each of which was of sufficient capacity for the entire work and both being provided to guard against delay in case of accident.

An interesting work now in progress is the Minidoka irrigation project of the U. S. Reclamation Service, in the south central part of Idaho. It embraces among other things a dam across the Snake River, a controlling works, and the headworks for a main irrigation canal at one end of this dam, and a long spillway and the headworks for a second main canal at the other end of the dam. The excavation of the diversion channel has been largely in lava rock, Ingersoll-Sergeant drills being used for the blast holes. Air for the drills was furnished by an Ingersoll-Sergeant compressor installed about 800 feet from the controlling works. The air was used also for operating the concrete mixer, the hoisting engines for the derricks used in connection with the cableways and for a pump at the river which supplied a system of water distribution extending to all parts of the work and to the construction camp.

RECENT U. S. PATENTS

MAY 21.

854,009. AUTOMATIC TIDAL AIR-COMPRESSOR. William O. Webber, Boston, Mass. Filed Sept. 17, 1906. Serial No. 334,992.

854,371. AIR-COMPRESSOR COMBINED WITH AN EXPLOSIVE-MOTOR. Andre Michelin, Paris, France. Filed Dec. 14, 1906. Serial No. 347,806.

854,694. PORTABLE PNEUMATIC TOOL. Charles H. Haeseler, New York, N. Y., and Albert H. Taylor, Easton, Pa., assignors to Ingersoll-Rand Company, a Corporation of New Jersey. Filed Dec. 8, 1906. Serial No. 346,969.

MAY 28.

855,050. COMPRESSOR. Charles W. Dietrich, Chicago, Ill. Filed Dec. 15, 1906. Serial No. 348,087.

855,433. PNEUMATIC DUST-REMOVER. Miles E. Freeman, Bradford, Pa., assignor of one-half to James J. Freeman, Bradford, Pa. Filed Aug. 24, 1905. Serial No. 275,586.

JUNE 4.

855,518. APPARATUS FOR ELEVATING WATER BY MEANS OF COMPRESSED AIR. Andrew M. Lockett, New Orleans, La. Filed June 25, 1906. Serial No. 323,253.

855,697. AIR-COMPRESSOR. Louis B. Cousans, Lincoln, England. Filed Feb. 28, 1905. Serial No. 247,771.

856,083. PNEUMATIC DRILL. Peter H. Murphy, St. Louis, Mo. Filed June 16, 1905. Serial No. 265,506.

856,109. PNEUMATIC TRANSMISSION SYSTEM. Joseph J. Stoetzel, Chicago, Ill. Filed March 14, 1906. Serial No. 305,960.

855,976. DROP-HAMMER. Carl Prott, Hagen, Germany. Filed June 9, 1906. Serial No. 321,020.

856,194. PNEUMATIC-TOOL HANDLE. Frederick S. Graham, Philadelphia, Pa., assignor of one-third to Ralph M. Seaman and one-third to Charles A. Struntz. Filed Nov. 9, 1906. Serial No. 342,713.

856,145. HAND-HOLE FOR PNEUMATIC-TUBE SYSTEMS. Walter V. Hart, Maywood, and Frank J. Novak, Chicago, Ill. Filed Oct. 25, 1906. Serial No. 340,504.

JUNE 11.

856,510. PNEUMATIC VEHICLE-SPRING. George W. Bell, Liverpool, England. Filed June 22, 1906. Serial No. 322,810.

856,636. PUMPING MACHINERY. Charles L. Heisler, St. Marys, Ohio. Filed Oct. 5, 1906. Serial No. 337,650.

856,651. PNEUMATIC DRILL. Peter H. Murphy, St. Louis, Mo. Filed Dec. 11, 1905. Serial No. 291,248.

856,706. PNEUMATIC TOOL. William H. Keller, Philadelphia, Pa. Filed Jan. 9, 1906. Serial No. 295,230.

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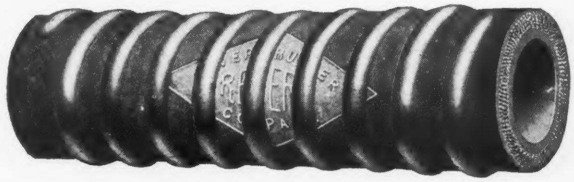

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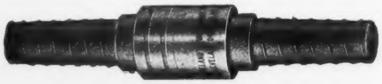

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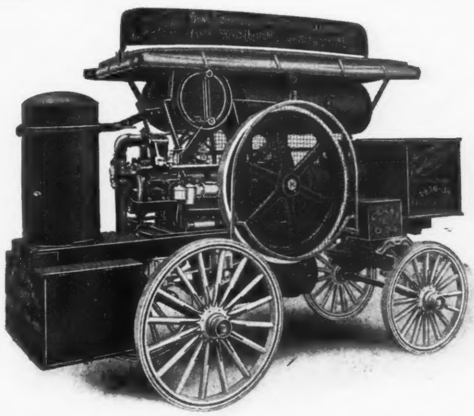

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